Agriculture
Canada

Publication 5126

A Review

of Research into Egg Production and Marketing

Proceedings of the conference organized jointly by the Canadian Egg Producers Council and the Canadian Egg Marketing Agency, and held October 1-3, 1979, at Ottawa, Canada.

Editor: John E. Lancaster, Agriculture Canada.

Published 1980
Agriculture Canada

PUBLICATION 5126, available from
Information Services, Agriculture Canada, Ottawa K1A 0C7

Cat. No. A-73-5126/1980E ISBN: 0-662-10876-0
Printed 1980 650--7:80

PREFACE

These proceedings are the outcome of views first expressed in 1977 at the semi-annual meeting of the Canadian Egg Producers Council. It was considered that an assessment of research knowledge and priorities was needed for a large sector of the poultry industry. Attention was directed to aspects of egg production at the farm level.

It was decided that all conference papers, namely, the advance working paper, the review of extension work, the assessment of current research knowledge and the summary report, would be distributed by the Canadian Egg Producers Council and the Canadian Egg Marketing Agency, co-sponsors of the meeting. It was also agreed that the proceedings would be edited and published by Agriculture Canada.

The main duty of the Editor was to review the material presented and assemble this under one cover. In undertaking this work, I wish to acknowledge with sincere thanks the detailed editorial assistance generously undertaken by staff of Information Services, Agriculture Canada. My sincere thanks also go to my Director for providing the opportunity to undertake this work. Although some changes have been made, I hope all the important features of the original material submitted to the conference have been retained. The responsibility for these changes is mine. Time did not permit obtaining clarification of some ambiguities.

I hope this publication will serve as a reference for those involved in egg production, and for libraries and library records in Canada and abroad.

John E. Lancaster
Ottawa, 1980

CONTENTS

TABLES

FIGURES

RAPPORT DE L'ATELIER SUR LA RECHERCHE EN MATIÈRE DE PRODUCTION ET DE COMMERCIALISATION DES ŒUFS
du 1er au 3 octobre 1979

Objectif

1. L'atelier a été chargé de porter son attention principalement sur la recherche et les besoins de services auxiliaires reliés à la production d'œufs au niveau de la ferme, à la manutention et à la gestion, y inclus la reproduction et l'élevage des pondeuses. Les participants n'ont pas abordé les problèmes de distribution ni de conditionnement au delà de la ferme, ni ceux de l'expansion du marché ou de la politique de la commercialisation en soi. A ce sujet, deux choses doivent être précisées. Premièrement, la structure de cet atelier n'implique aucune diminution de l'importance des autres secteurs relevant de l'industrie. En second lieu, les effets et l'importance économiques de la recherche sur la production et la gestion, et par conséquent, les décisions et les priorités relatives à la recherche, seront définitivement affectés par les facteurs du marché comme la nature de la demande du consommateur, la mise au point de nouveaux produits et le système de commercialisation lui-même. La chose a été démontrée un certain nombre de fois, par exemple, par le huilage des œufs à la ferme pour la rétention de la qualité et les implications de la reproduction en vue d'obtenir des œufs plus petits pour améliorer la qualité de la coquille et le taux de ponte.

Énumération des priorités de la recherche

2. Un des premiers résultats des délibérations de l'atelier, sur lequel les participants ont consacré beaucoup de temps, est l'énumération, par ordre, des priorités de recherche que l'on retrouve dans le tableau qui accompagne ce rapport. Cette liste fait part d'une énumération par catégorie quant aux délais requis. Elle est divisée en neuf sujets, et l'énumération tente de respecter ce regroupement. L'atelier est arrivé à la conclusion que le fait de tenter d'établir une liste générale des priorités parmi tous les groupes n'était pas possible, étant donné le peu de temps disponible, et que de plus, l'établissement des priorités d'une façon aussi complète fut influencé par de nombreux facteurs dont la disponibilité des compétences et des intérêts nécessaires du milieu scientifique et des installations requises pour se livrer à la recherche.

Préoccupations principales au sujet des priorités

3. Il est toutefois possible d'identifier les préoccupations principales des participants quant aux priorités, et certains aspects de divergence de vues.

4. On a fortement insisté sur le fait que le Canada doit maintenir des centres de recherche avicole et des programmes de recherche connexe sur une base qui permettra à l'industrie de ne pas perdre de terrain et d'atteindre les exigences à court et à long terme en vue d'une productivité accrue et d'une viabilité économique. Une importante composante de la planification, à cet égard, doit être d'accorder à la recherche l'appui requis, au niveau universitaire, dans le but de développer un système de formation supérieure pour assurer un personnel qualifié à l'industries. Ces concepts sont élaborés dans le document de travail préparé en vue de la tenue de l'atelier.

5. La recherche, sur les œufs, doit être coordonnée et interdisciplinaire. Les participants ont souligné qu'il fallait avoir recours à un programme équilibré de recherche—à court et à long terme; recherche fondamentale et recherche appliquée. Il faut tenir compte de cet équilibre lors de l'attribution des priorités. Une approche d'équipe, au sein de laquelle toutes les disciplines de recherche contribuent à résoudre les problèmes, donnera les meilleurs résultats aux producteurs.

6. La recherche relative à la production d'œufs a été étudiée par les participants à l'atelier sous les chapitres suivants:

- Comportement et bien-être de la pondeuse
- Commercialisation des œufs et des pondeuses
- Équipement, conception des installations mécaniques et logement
- Génétique et reproduction
- Santé du troupeau des pondeuses
- Métabolisme et endocrinologie
- Nutrition: énergie et protéines
- Nutrition: sels minéraux, vitamines et antibiotiques
- Gestion du troupeau des poulettes et des pondeuses.

7. Lors de la revue du travail des sous-groupes qui ont examiné ces domaines de recherche, l'atelier a insisté sur le besoin de faire des recherches sur place dans le but de procéder à des expériences dans un milieu qui ressemble autant que possible aux conditions réelles de vie d'un troupeau de pondeuses. Une telle mesure peut être coûteuse et nécessiter la collaboration des producteurs d'œufs. On a également insisté sur le besoin de résultats de recherche qui tiennent pleinement compte de notre climat particulièrement froid.

8. Certains groupes ont considérablement insisté sur le besoin d'améliorer la qualité de la

coquille. C'est un problème qui exige une approche interdisciplinaire dans laquelle la psychologie, la technique, la reproduction et d'autres disciplines doivent être représentées. On a reconnu en même temps que l'on possède beaucoup plus de connaissances sur la façon d'assurer un meilleur rendement, quant à la qualité et au bris de la coquille, au moyen d'une bonne nutrition et d'une gestion adéquate, mais que toutes ces connaissances ne sont pas appliquées et qu'il est de la première importance de bénéficier de services auxiliaires accrus à cet égard. C'est une question qui intéresse au premier plan la majorité des producteurs.

9. Les participants ont accordé une faible priorité à la mue forcée à cause de la préférence marquée des Canadiens pour une période unique de ponte, suivie du remplacement du troupeau. Les facteurs économiques influençant les producteurs en font de loin la pratique dominante. Des systèmes optimaux de provocation d'une seconde période de ponte ont toutefois été mis au point aux États-Unis. Nous ne possédons pas l'expérience voulue pour les appliquer et la nature même du système régulateur de commercialisation peut militer contre le recours à cette option.

10. Les producteurs envisagent la recherche en fonction de leurs besoins, et à leurs yeux, la recherche agricole doit se faire en fonction des besoins des producteurs. On s'est toutefois demandé si les besoins des producteurs, en fait de recherche, étaient bien identifiés. Pour certains producteurs, le monde de la recherche est un monde nouveau et la communication efficace n'a pas encore été établie. Bien que les participants insistent grandement sur le besoin de recherche à court et à long terme, le financement par les associations de producteurs (et d'autres groupements de l'industrie) peut très bien favoriser des projets à plus court terme ayant des objectifs plus immédiats et plus clairement définis. Le producteur tend à accorder la priorité à la recherche qui promet des avantages concrets de réduction de coûts. Il est entendu que ces travaux de recherche financés par les producteurs devront se faire dans le cadre de la recherche entreprise au Canada sur la production d'œufs, avec une communication efficace entre les producteurs, l'industrie et le milieu scientifique.

11. Les considérations relatives au bien-être des animaux doivent constituer une préoccupation importante du producteur et de la population. L'atelier a identifié un besoin hautement prioritaire en faveur d'une étude objective et franche sur «ce qui est normal» dans le comportement de la pondeuse. Cette banque de données fournira un moyen d'établir des normes de traitement humanitaire. Le producteur et le public ont des intérêts marqués dans une productivité qui résulte de l'amélioration des aspects de la recherche sur le bien-être de l'animal et du traitement humanitaire des animaux sur lequel la recherche peut faire la lumière. On ne peut pas supposer non plus que ces deux objectifs soient nécessairement en conflit.

Services auxiliaires

12. Un souci constant manifesté au cours de l'atelier a porté sur l'importance des services auxiliaires. Tous étaient d'accord pour dire que les connaissances actuelles sur l'amélioration des pratiques d'alimentation et de gestion ne sont pas utilisées au maximum. Les services auxiliaires constituent un sujet important en soi. L'assemblée n'a pas abordé ces services en détail. On a toutefois souligné ce qui suit:

13. —Il faut tenir compte des rôles et des responsabilités des gouvernements, des universités, des organisations de producteurs et des autres secteurs de l'industrie.

14. —La recherche devrait inclure des essais régionaux d'application commerciale. Il est pertinent de soulever ce point dans le contexte des services auxiliaires parce qu'il a trait de façon importante au niveau selon lequel les résultats de la recherche sont appliqués et adaptés efficacement aux besoins commerciaux de même qu'au degré de confiance que les producteurs auront dans les recommandations découlant de la recherche.

15. —On a proposé de trouver des moyens de mettre à la disposition des producteurs les résultats de la recherche dans une langue qu'ils peuvent comprendre. Le volume véritable de données, et sa nature changeante, peuvent rendre cette pratique coûteuse. Il peut toutefois être possible de fournir aux non initiés l'interprétation des principaux problèmes de façon à répondre aux questions les plus fréquemment posées, soit au moyen d'un ordinateur, soit au moyen de brochures. Une telle mesure aiderait particulièrement les producteurs vivant dans les régions éloignées des services vétérinaires.

16. —La surveillance de la présente expérience commerciale des producteurs, en termes de type particulier d'entreprises quant à la dimension, à l'équipement, aux méthodes de gestion, ainsi de suite, constituera un outil auxiliaire utile pour faire connaître aux producteurs le rendement commercial et les problèmes rencontrés. Elle pourrait, à des fins scientifiques, constituer un moyen valable pour identifier les problèmes qui, pouvant être rencontrés un à un par hasard, n'en paraissent pas moins importants du point de vue statistique, de façon générale ou dans certaines régions. La surveillance peut fournir la base d'une évaluation utile de l'application des résultats de la recherche.

17. —L'incidence d'un grand nombre de maladies de la volaille n'est pas connue de façon fiable à cause d'un manque général de surveillance autre

que les cas cliniques. L'incidence sous-clinique, et les maladies endémiques, a-t-on laissé entendre, devraient être identifiées plus clairement en procédant à un examen systématique en laboratoire d'oiseaux vivants ou morts dans des troupeaux choisis. Les renseignements obtenus d'une telle incidence montreraient concrètement aux producteurs la gravité de ces maladies de même que l'importance des mesures préventives. Dans certains cas, l'éradication de la maladie est possible si le diagnostic est évident.

Financement

18. L'atelier a reconnu que le financement de la recherche traverse une période de restriction. Certains budgets sont actuellement réduits. Cela pose le danger de l'insuffisance générale du financement de la recherche. Une telle austérité financière peut également mener à la négligence de types spécifiques de recherches coûteuses malgré leur valeur et leur importance. On s'est particulièrement inquiété du financement des universités et de leur capacité à maintenir leurs programmes supérieurs. Il est également souhaitable que des subventions à la recherche et au développement soient mises à la disposition des petites entreprises. On a fait savoir que le Conseil canadien de recherche agricole procède actuellement à un examen de ses besoins de recherche et de la possibilité d'obtenir des fonds à cette fin, ce qui est une entreprise importante.

19. Les restrictions dans le financement public laissent clairement entendre que les secteurs non gouvernementaux doivent évaluer leurs propres responsabilités. On a clairement indiqué toutefois, que l'assemblée ne considère pas que les fonds de l'industrie devraient compenser pour ces réductions du financement public. De tels montants ne peuvent probablement pas être obtenus des producteurs ni d'autres sources privées. Il existe également un très vaste intérêt public dans l'amélioration de la productivité permise par la recherche et il semblerait approprié et essentiel de pouvoir compter sur le financement public.

20. On a longuement discuté de l'intérêt de l'Office canadien de commercialisation quant au financement de la recherche relative à l'industrie des œufs. Des représentants de l'OCCO ont indiqué que la participation de cet organisme au financement de la recherche était probable (on a également souligné qu'une importante aide financière à la recherche est assurée par certains offices provinciaux de commercialisation des œufs). Aucune décision concrète n'a cependant été prise sur la nature de ce financement de l'OCCO et un aspect important de cet intérêt à l'atelier fut d'aider sa considération à cette question. En se déchargeant de ses activités de financement de la recherche, l'OCCO proposerait d'établir des processus de consultation pour faire en sorte que l'on tienne compte des besoins des producteurs, qu'il y ait coordination avec le gouvernement pour s'assurer que les décisions sont prises à la lumière de l'ensemble de la recherche et que l'on obtienne des conseils de la part du milieu scientifique relativement à l'évalution et à l'élaboration de projets de recherche. L'atelier a surtout insisté sur l'importance de ce dernier aspect du processus et a noté certains mérites relatifs du financement par subventions par rapport au financement par contrats.

Processus de consultation et de coordination

21. Les participants à l'atelier ont exprimé l'espoir que ce rapport et les documents de travail qui l'accompagnent constitueront une ressource utile pour la considération des besoins de recherche et de services auxiliaires de l'industrie des œufs, de ses défis et de ses priorités.

22. Les producteurs, à titre d'usagers de la recherche, doivent soumettre leurs recommandations et doivent être écoutés en ce qui a trait au choix du mode de financement des sujets de recherche et des travailleurs de la recherche. L'atelier a proposé que l'OCCO établisse un comité spécial chargé d'examiner les conclusions de l'atelier et, si la chose se révèle souhaitable, de former une espèce de consultation permanente entre les producteurs et les hommes de science. Les objectifs du premier comité de l'OCCO pourraient être:

(i) d'établir une organisation permanente au moyen de laquelle les producteurs d'œufs pourraient contribuer au programme d'ensemble de recherche relative à la production d'œufs au Canada;

(ii) de coordonner les efforts de la recherche directement reliée à l'industrie;

(iii) d'établir des moyens organisés de diffuser les renseignements sur les résultats de la recherche à l'industrie.

Les buts du sous-comité des œufs (du CCCSA) devraient être assurés et les possibilités de coordination ou de chevauchement avec l'organisation consultative proposée des producteurs et des savants révisées. On a souligné l'importance que toutes les disciplines de la recherche soient représentées au sein d'un tel organisme consultatif.

Observations d'intérêt découlant des discussions

23. Dans le domaine extrêmement important relativement aux coûts des pratiques d'alimentation, on a fait remarquer:

- —La première priorité est d'améliorer l'efficacité de l'utilisation des protéines (acides aminés) et de l'énergie. Une bonne partie du travail implique une évaluation plus juste des nutriments disponibles dans l'alimentation de même que la caractérisation des exigences des pondeuses.
- —Les procédures de gestion qui réduisent les besoins d'énergie méritent également une haute priorité. Des exemples de ces dispositions incluent des températures élevées dans les poulaillers et des programmes de restriction alimentaire. Pour obtenir une efficacité optimale de l'utilisation de l'alimentation, il faut une méthode juste de mesurer la consommation de l'alimentation.
- —L'effort continu pour utiliser de nouvelles sources d'énergie et de protéines demeure hautement prioritaire.
- —On s'est également inquiété d'un manque possible de compétence professionnelle pour fournir à l'industrie de la volaille des renseignements sur la nutrition.
- —On a discuté de la possibilité pour les producteurs, étant donné le prix élevé des aliments, de réduire de façon profitable l'apport alimentaire de leurs troupeaux de pondeuses, particulièrement en ce qui a trait au contenu protéique, même s'il devait y avoir une baisse de la production d'œufs. On s'est entendu pour affirmer que l'on avait tendance à donner de trop fortes quantités de protéines. On a également déclaré que bien que l'apport diététique pouvait affecter la composition de gras et le niveau vitaminique de l'œuf, rien ne prouve que la composition protéique de l'œuf ne soit affectée par des variations de l'apport en protéines, un fait qui, de l'avis général, n'est pas compris comme il devrait l'être.

24. On a souligné que certains problèmes actuels importants relatifs à la maladie pourraient être contrôlés au moyen de techniques de gestion avec l'aide des laboratoires, ajoutant que les producteurs ont besoin de plus d'aide des laboratoires dans la surveillance de leurs troupeaux quand ils tentent de contrôler ces maladies. On a indiqué que les priorités de la recherche dans ce groupe devaient être décidées sur la base de l'importance du problème et non sur le fait de savoir si un problème pouvait être résolu par la recherche pure, la recherche appliquée, une enquête sur place ou la surveillance des laboratoires.

25. On s'est beaucoup inquiété, surtout en ce qui a trait à la maladie de Marek, de l'importance de la surveillance et de la recherche continue pour prémunir l'industrie contre le risque de l'émergence d'agents pathogènes qui ont acquis une résistance aux méthodes actuelles de traitement, et de l'introduction, au Canada, d'agents pathogènes venant de l'étranger. On a décrit comme une «surveillance diagnostique» le concept d'un système spécial de détection hâtive de la maladie.

PRIORITÉS DES RECHERCHES FUTURES

GÉNÉTIQUE ET REPRODUCTION

	Priorité	Terme
On doit poursuivre la recherche sur les méthodes d'amélioration des techniques de sélection et mettre l'accent sur l'élaboration de programmes de sélection à traits multiples qui incluent l'efficacité de l'alimentation comme l'une des caractéristiques principales.	haute	long
Les techniques génétiques pour l'amélioration de la qualité de la coquille, l'amélioration générale de la résistance à la maladie, l'amélioration de la persistance dans le taux de production et du rendement après la mue, à l'intérieur des programmes de sélection destinés à produire une pondeuse qui possède les caractéristiques requises pour une production efficace d'œufs destinés au marché sont requises.	haute	long
Études sur la provenance de caractéristiques de comportement pour voir s'il est possible de sélectionner des pondeuses ayant le type de comportement qui favorise la production d'une forte quantité d'œufs de haute qualité.	haute	long
Domaines précis de recherche fondamentale relative à la recherche appliquée, par exemple l'évaluation de paramètres bicchimiques et physiologiques directement liés à la sélection en vue d'un rendement économique.	haute	long
Recherche sur l'interaction entre le génotype et l'environnement en vue de continuer et d'étendre ce secteur de la recherche; d'élucider une compréhension plus précise des besoins particuliers de souches et d'espèces; de mettre au point des régimes alimentaires nutrititionnels et physiologiques pour maximiser le rendement; d'incorporer des méthodes plus précises au sein des programmes de sélection pour combattre le stress et comprendre pourquoi les oiseaux répondent ou réagissent différemment à divers milieux.	haute	long
On devrait fournir les ressources nécessaires à l'identification et au maintien des éléments mutants au fur et à mesure qu'ils surgissent dans les programmes de reproduction, afin de pouvoir étudier leur utilisation possible dans le secteur industriel et des les exploiter à des fins de recherche en physiologie et en génétique.	haute	long

NUTRITION: ÉNERGIE ET PROTÉINES

(a) court terme	Ordre de priorité	Terme
1. Comparaison des nouveaux bioessais rapides de détermination de l'EMA (énergie métabolisable apparente) et de l'EMR (énergie métabolisable réelle) avec les méthodes classiques de mesure de l'EM (énergie métabolisable) quant à leur facilité, leur précision et la possibilité de reproduire les déterminations, le rendement biologique et le coût.	1	court
2. Établissement d'une méthode standard de détermination de l'EM.	2	court
3. Adoption d'un type unique de valeur de l'EM pour l'expression des valeurs énergétiques des aliments et des besoins en énergie de la volaille en collaboration avec un organisme tel que le Comité de spécialistes sur l'alimentation animale.	3	court
4. Établissement d'une méthode standard de mesure de la quantité d'acides aminés disponibles dans l'alimentation.	4	court
5. Définition plus précise de la relation entre l'apport d'énergie, de protéines et d'acides aminés et la production d'œufs, dans le but d'établir un modèle économique complet d'apport-production.	5	court

PRIORITÉS DES RECHERCHES FUTURES (suite)

NUTRITION: ÉNERGIE ET PROTÉINES

(a) court terme	Ordre de priorité	Terme
6. Régimes alimentaires qui auraient pour résultat des gains minimaux de poids à la maturité afin de réduire les coûts d'entretien et améliorer la santé de l'oiseau. Un tel programme impliquerait le développement de façons pratiques de contrôler l'apport énergétique des pondeuses et l'évaluation économique des programmes alimentaires restreints.	6	court
7. Évaluation économique de l'élévation de la température dans le poulailler pour réduire les coûts énergétiques d'entretien.	7	court
8. Amélioration de la valeur nutritive des céréales et des grains au moyen de techniques de reproduction par suite de la mise au point d'essais biologiques et chimiques rapides de mesure de la qualité disponible d'énergie et d'acides aminés dans les nouvelles récoltes. On a aussi besoin d'essais rapides et peu dispendieux pour déterminer la valeur nutritive des aliments et des régimes alimentaires mélangés.	8	court
9. Étude de la valeur relative du maïs dans le régime alimentaire de la pondeuse. Il s'agit là d'un sujet qui prête à controverse dans l'Ouest du pays et les fabricants d'aliments aimeraient posséder plus de renseignements à ce sujet.	9	court
10. Établir les mérites relatifs de la texture de l'alimentation, soit les boulettes, les miettes ou la purée, sur une base économique.	10	court
11. Enquêtes sur les techniques de conditionnement, comme le traitement aux enzymes et à la chaleur, pour améliorer la quantité de nutriments disponibles.	11	court
12. Étude sur la valeur du grain entier, étendue de façon à porter également sur le grain humide.	12	court
13. Influence de la sinapine du colza sur la saveur des œufs.	13	court
(b) Long terme		
1. Établissement des besoins d'acides aminés des pondeuses.	1	long
2. Interaction de la génétique et de la nutrition sur le syndrome hémorragique du foie et les autres problèmes.	2	long
3. Recherche sur l'utilisation de protéines indigènes comme la graine de colza pour réduire notre dépendance des protéines importées. La valeur nutritive des aliments protéiques comme les pois de grande culture, la fève des marais et la graine de soleil devrait être établie.	3	long
4. Connaissance de base accrue des besoins digestifs et d'absorption dans le but d'améliorer l'efficacité de l'utilisation des provendes. Il semble par exemple que l'efficacité de l'utilisation des aliments soit supérieure chez le porc, ce qui pourrait laisser croire à une amélioration possible.	4	long
5. Établissement de la possibilité des suppléments d'acides aminés au régime alimentaire de la pondeuse.	5	long
6. Réévaluation période des besoins nutritifs de la pondeuse au fur et à mesure de l'introduction de nouvelles variétés génétiques.	6	long
7. Établissement de la valeur nutritive des grains, surtout des nouvelles variétés.	7	long
8. Poursuite du travail et recherche nouvelle sur d'autres sources de protéines comme les grains en haute teneur en protéines, la luzerne déshydratée et les résidus et sous-produits industriels et agricoles.	8	long

NUTRITION: SELS MINÉRAUX, VITAMINES ET ANTIBIOTIQUES

	Priorité	Terme
Sels minéraux:		
Réévaluation des besoins de sels minéraux à tous les âges de la poulette et de la pondeuse.	haute	5 ans
Besoins de sélénium de la pondeuse et apport à l'œuf et aux muscles.	moyenne	5 ans
Identification des besoins optimaux de phosphore de la pondeuse.		
Étude du métabolisme du calcium relativement à la qualité de la coquille.	moyenne	5 ans
Utilisation de régimes alimentaires faibles en sodium pour contrôler la maturité de la poulette.	faible	5 ans
Étude du métabolisme des métaux lourds chez la pondeuse.	faible	5 ans
Vitamines:		
Étude de la stabilité de la vitamine lors de l'entreposage à la ferme.		
Étude des besoins de vitamines chez la pondeuse.	haute	5 ans
Poursuite des études en cours sur le rôle des diverses métabolites de la vitamine D_3 dans l'équilibre du calcium et du phosphore en rapport avec la qualité de la coquille.	moyenne	5 ans
Étude de la vitamine E—réaction au sélénium.	moyenne	5 ans
Étude des besoins en vitamine B chez le poulet, la poulette, la pondeuse et le reproducteur en insistant sur l'élucidation des antagonistes diététiques.	faible	5 ans
Antibiotiques:		
Élaboration de systèmes de gestion dépendant moins des antibiotiques.	faible	5 ans
Recherche de nouveaux antibiotiques en tenant compte de la résistance de l'organisme, exemple, les salmonelles.	faible	5 ans

MÉTABOLISME ET ENDOCRINOLOGIE

		Priorité	Terme
1.	Métabolisme du calcium.	1. haute	long
2.	Rythmes circadiens (un par jour).	2. haute	long
3.	Régulation endocrine de la formation de l'œuf.	3. haute	long
4.	Croissance et maturité sexuelle.	4. moyenne	moyen
5.	Caractérisation physiologique de souches génétiquement divergentes.	5. moyenne	moyen
6.	Congélation du liquide séminal.	6. moyenne	court
7.	Physiologie du stress.	7. moyenne	long
8.	La glande thyroïde.	8. faible	long
9.	Métabolisme des lipides.	9. très faible	long
10.	Mue forcée.	10. très faible	court

PRIORITÉS DES RECHERCHES FUTURES—(*suite*)

SANTÉ DU TROUPEAU DES PONDEUSES

	Priorité	Terme
Procédures d'identification des pondeuses atteintes de leucose lymphoïde.	haute	modéré
Éradication du mycoplasma gallisepticum. Possibilité de nouveaux laboratoires pour identifier les troupeaux infectés.	haute	relativement court
Mise au point de techniques de diagnostics pour identifier et contrôler les agents pathogènes causant des coquilles anormales ou des baisses de production (bronchite infectieuse, infections par adénovirus, encéphalomyélite aviaire) et autres conditions causant des anormalités à la qualité interne de l'œuf.	haute	long
Recherche sur la façon d'isoler le virus, les mécanismes d'immunisation et l'utilisation de vaccins pour combattre la maladie Marek.	haute	long
Recherche sur l'importance de la maladie des bourses et des vaccins pour en assurer le contrôle.	haute	modéré
Amélioration des vaccins contre la laryngotrachéite infectieuse.	moyenne	modéré
Recherche sur le développement de la résistance aux drogues utilisés dans le traitement de la coccidiose et les autres méthodes de contrôle comme les mécanismes d'immunisation.	moyenne	long
Le syndrome de l'ostéomalacie.	moyenne	modéré

GESTION DU TROUPEAU DES POULETTES ET DES PONDEUSES

		Priorité	Terme
1.	La qualité de la coquille (a) production de coquilles adéquates (b) amélioration des techniques de gestion et de manutention	haute	
2.	Conception de la cage (a) étude de programmes de gestion et de nutrition compatibles avec le modèle de la cage	haute	
3.	Conservation de l'énergie (a) systèmes d'éclairage (b) systèmes de couvaison (c) efficacité de l'alimentation	moyenne	long
4.	Possibilité économique de la mue forcée chez la pondeuse	faible	
5.	Gestion des résidus	faible	
6.	Qualité de l'albumen (a) nouveaux sondages pour connaître les désirs du consommateur (b) nouvelles études s'il existe vraiment un problème de commercialisation	faible	

COMPORTEMENT ET BIEN-ÊTRE DE LA PONDEUSE

		Priorité	Terme
1.	Étude éthologique pour mesurer «ce qui est normal» dans le comportement de la pondeuse.	1	
2.	Amélioration du design des cages.	2	
3.	Études détaillés de l'environnement et du comportement, à la ferme.	3	
4.	Élaboration d'un code de pratique pour manipuler la pondeuse depuis le couvoir jusqu'à l'abattoir.	4	
5.	Formation des gardiens à l'université ou au collège communautaire.	5	

PRIORITÉS DES RECHERCHES FUTURES—(suite)

COMMERCIALISATION DES ŒUFS ET DES PONDEUSES

		Priorité	Terme
1.	Programme sanitaire efficace au poste de classement des œufs: à cause des problèmes reliés au lavage des œufs, on devrait trouver d'autres moyens de nettoyer les œufs, qu'il s'agisse d'un système de lavage plus efficace ou d'un tout autre système qui élimine le besoin de laver les œufs.	haute	
2.	Étude de faisabilité sur l'effet de la pénétration bactérienne de l'albumen sur la qualité.	haute	
3.	Besoin d'un résumé de la recherche sur la coquille à l'intention des producteurs.	haute	
4.	Comment améliorer le pelage des œufs huilés.		
5.	Recherche en matière de commercialisation sur un jaune de couleur uniforme partout au Canada.		
6.	Acceptation d'un nouvel emballage. Devrait-il y avoir plus ou moins d'œufs par boîte?		
7.	Nouveaux moyens d'utiliser les pondeuses épuisées. Vente d'œufs au kilogramme	faible	
	Étude pour supporter ou réviser les tableaux publiés des valeurs de certains éléments clé de la composition chimique et nutritive des œufs.	faible pour la recherche	
	Maintien de la surveillance sur la recherche sur le cholestérol.	haute pour transfert technologique faible (en douceur)	
	Considérer une différente façon d'évaluer le qualité intérieure de l'œuf (autre que le mirage).	faible (problème industriel)	
	Rétention de la qualité intérieure.		faible
	Production obligatoire d'une coquille solide.	haute pour recherche générale faible pour recherche en commercialisation	

ÉQUIPEMENT, CONCEPTION DES INSTALLATIONS MÉCANIQUES ET LOGEMENT

		Priorité	Terme
1.	Conception de systèmes complets: a. de sur place du rendement des divers bâtiments et des systèmes d'équipement agricole, b. service auxiliaires pour diffuser les renseignements disponibles aux producteurs.	haute	court
2.	Conservation de l'énergie dans les bâtiments existants et au moyen de la mise au point d'une nouvelle technologie destinés aux bâtiments actuels et futurs:		
	a. services auxiliaires pour appliquer des ventilateurs plus économiques aux bâtiments actuels et futurs,	haute	court
	b. recherche pour mettre au point des systèmes de ventilation qui reprend la chaleur perdue,	haute	court à moyen
	c. aide aux fabricants pour la mise au point de ventilateurs plus économiques,	moyenne	moyen
	d. recherche sur l'énergie solaire.	faible à moyenne	long
3.	Conditionnement et manutention des provendes à la ferme.	auxiliaire	
4.	Design des cages	moyenne	long
5.	Cueillette des œufs: comparison économique entre la cueillette manuelle et la courroie.	haute	court

ÉQUIPEMENT, CONCEPTION DES INSTALLATIONS MÉCANIQUES ET LOGEMENT

6.	Systèmes de surveillance et de communication: Étape 1: définir le marché Étape 2: chercher à mettre au point des systèmes de surveillance appropriés pour des troupeaux de 5000 à 10 000 pondeuses. Cette recherche devrait se faire au moyen de subventions aux compagnies.	haute	court
7.	Continuer de mettre au point de nouveaux designs de poulaillers.	faible	long
8.	Problème du fumier humide dans les poulaillers en hauteur: recommander que les immeubles soient construits de façon à recueillir le fumier sous une forme semi-solide.	moyenne	moyen
9.	Au sujet de la liquidation des oiseaux, on recommande l'entreposage au congélateur à la ferme des oiseaux morts et une livraison périodique à l'industrie de disposition des animaux morts.		

Current Research

Current research into Canadian egg production and marketing[1], as determined for the year 1979 is summarized in this section.

Egg production and marketing research[2] is currently being performed by 117 scientists[3] in 16 government and university institutions in Canada. Individually and as teams, they are engaged in 185 research projects.

Of the 16 institutions, Table 1 shows that Agriculture Canada and the University of Guelph predominate, and that the universities of British Columbia and Manitoba, and Macdonald College are also important in the conducting of egg production and marketing research.

The research projects on which the scientists were engaged during 1979 are listed in Table 2. It should be understood that the list does not indicate which of the projects are long-term and which are short-term. A single project, e.g., the one on evaluation of poultry feeding stuffs, may very well continue for a decade or more. The duration of other projects may be as short as a year. In particular, it is likely that Table 2 does less than justice to the considerable long-term research in genetics performed by Agriculture Canada.

The research projects have been classified as having specific or general relevance. Forty-four projects, which are listed as having specific relevance, are of direct importance to egg production, e.g., the project on force-molting of layers. Research projects classified as of general relevance, such as the study on fibre in poultry diets, usually have application to both egg producers and other poultry producers. Some of the general research projects may have more immediate application to turkey or broiler producers, but are included

TABLE 1. Number of Scientists Engaged in Egg Production and Marketing Research Projects, by Institution

Research agencies	Number of scientists	Projects listed Relevance Specific	Projects listed Relevance General
Government			
Agriculture Canada	41	18	41
British Columbia Agriculture	1	—	6
Alberta Agriculture	3	2	2
Ontario Agriculture	1	2	—
Quebec Agriculture	1	1	—
New Brunswick Agriculture	—	—	—
Sub-total	47	24	49
Universities & Colleges			
Guelph	36	5	35
British Columbia	8	2	21
Manitoba	8	2	12
Alberta	2	1	6
Saskatchewan	2	1	3
Laval	2	0	2
École de Médecine Vétérinaire, St. Hyacinthe	2	0	1
Toronto	1	0	1
Macdonald College	8	4	8
Nova Scotia Agricultural College	1	5	3
Sub-total	70	20	92
Total	117	44	141

[1] Egg marketing research in this text refers to studies on egg production problems that affect marketing, e.g., eggshell quality, interior egg quality, odor.

[2] See SOURCES No. 1-4, (page 31).

[3] 'Project leaders and established professional staff' according to the Canadian Agricultural Research Council inventory of Canadian research, and 'researchers' according to W. Guenter.

TABLE 2. Research Projects: Egg Production and Marketing

Institution	Relevance Specific	Relevance General	Title
GENETICS AND BREEDING			
Agr. Canada	x		Genetic techniques for controlling Marek's disease (MD) and for simultaneous improvement of multiple economic traits in high-performance egg-production chickens.
Agr. Canada	x		Effect of selection for egg production in two strains of S.C. white leghorns.
Agr. Canada	x		Long-term selection for improvement of egg stocks of poultry for the complex traits required in commerce.
Agr. Quebec	x		Amélioration des lignes de pondeuses du Québec en vue de la production d'un hybride à haut rendement.
Agr. Canada, Alta.		x	Investigation of rate of genetic gain obtainable under a program of pullet and cockerel selection based entirely on part-year records.
Macdonald College		x	Genetic selection for viability of frozen avian spermatozoa metabolism.
Univ. of Guelph		x	Breeding program for genetic stocks maintained in small populations.
Univ. of B.C.		x	Genetic differences in nutrient requirements.
NUTRITION			
Agr. Canada, N.S.	x		Nutrition—physiology of egg-production stocks.
Univ. of Guelph	x		Relationship between feeding behavior, feed conversion and profitability of the laying hen.
Univ. of Guelph	x		Strain effect in converting feed to egg solids.
Univ. of Guelph	x		Nutrient requirements of growing pullets and laying hens.
Univ. of Guelph	x		Factors affecting feed efficiency in the laying hen.
Agr. Canada, N.S.		x	Chicken and turkey broiler nutrition—physiology.
Agr. Canada		x	Measurement of available energy in feedstuffs.
Agr. Canada		x	Evaluation of poultry feedstuffs.
Agr. Canada		x	Nutrition and management of meat-type breeding stock.
Agr. Canada, Sask.		x	Effect of dietary fat and energy on performance and carcass caracteristics of turkeys.
Agr. Canada, Sask.		x	Crude protein: energy relationship in diets of growing turkeys.
Agr. Canada, Sask.		x	Utilization of rapeseed and rapeseed products in diets of growing turkeys.
Agr. Canada, Sask.		x	Evaluation of feedstuffs in diets for growing turkeys.
Agr. Canada, Sask.		x	Elucidate the amino acid requirements of the growing turkey and study the availability of amino acids in intact protein services.
Agr. Canada, Alta.		x	Nutritive value of new energy and protein sources for poultry.
Agr. Canada, Alta.		x	Mineral requirements of chickens as influenced by breed and strain of chicken and levels of other nutrients.

TABLE 2 (continued)

Institution	Relevance Specific	General	Title
NUTRITION (cont'd)			
Agr. Canada, Alta.		x	Effects of mineral levels in water on production traits of poultry.
Alta. Agriculture		x	Rapeseed gums feeding test.
Univ. of Guelph		x	Processing feed ingredients.
Univ. of Guelph		x	Poultry excreta nutrients available to the ruminants.
Univ. of Guelph		x	Protein evaluation.
Univ. of Toronto		x	On the development of food preferences in young chicks.
Univ. of Manitoba		x	Evaluation of lathyrus and lentils as a feedstuff for poultry.
Univ. of Manitoba		x	Fiber in poultry diets.
Univ. of Manitoba		x	Utilization of rye as a major constituent in diets of poultry and laboratory animals.
Univ. of Manitoba		x	Water quality for poultry.
Univ. of Manitoba		x	Anti-nutritional factors in the small vicia faba-bean.
Univ. of Manitoba		x	An investigation of the factors affecting the nutritive value of rapeseed products.
Univ. of Manitoba		x	Nutritive evaluation of energy feedstuffs for poultry.
Univ. of Guelph		x	Dietary factors affecting organoleptic properties and carcass quality of poultry.
Univ. of Guelph		x	Malonaldehyde content of food.
Univ. of Alberta		x	Evaluation of non-rapeseed components from rapeseed in rations for poultry.
Univ. of Alberta		x	Nutritional value of rapeseed meal.
Univ. of Alberta		x	Nutritive value of protein-rich feedstuffs.
Univ. of Alberta		x	Rapeseed meal studies.
Univ. of Alberta		x	The role of dietary and hormonal factors in the nutrition of chicken and poults.
Univ. of B.C.		x	Thyroid nutrition interrelationships in the chicken.
Univ. of B.C.		x	Lipids in poultry nutrition.
Univ. of B.C.		x	Availability of amino acid in feedstuffs for chicks, efficiency of feed utilization in poultry, utilization of animal waste.
Agr. Canada, N.S.		x	Effect of level of dietary protein on the performance of broiler breeders and hatchability of eggs.
Agr. Canada, N.S.		x	Effect of rapeseed meal in breeder diets on performance and hatchability.
Univ. of B.C.		x	Antibiotics as growth stimulants in broiler feeding.
Univ. of B.C.		x	Selenium responsive condition.
Univ. of Alberta		x	Role of vitamins in poultry nutrition.
Univ. of Manitoba		x	Mineral availabilities in feed grains.
Agr. Canada, N.S.		x	Evaluation of a new source of high-quality dietary protein for poultry—squid meal.
Agr. Canada, N.S.		x	Evaluation of the nutritional worth of rapeseed meals for broilers, growers and adult birds.

TABLE 2 (continued)

Institution	Relevance Specific	General	Title
NUTRITION (cont'd)			
Univ. of B.C.		x	Rapeseed products in poultry feeding.
Univ. of B.C.		x	Wheat screenings in breeder diets.
Univ. of B.C.		x	Feed-grain evaluation.
Agr. Canada, B.C.		x	The value of muka as a feedstuff.
Univ. of Manitoba		x	Fiber nutrition of meat-type breeding stock.
Agr. Canada		x	Biliogical availabilities of amino acids of cereal grains.
Univ. of B.C.		x	Factors affecting amino acid and mineral availability of feed ingredients.
Alberta Agr.		x	Various varieties of rapeseed meal in starter, growing and layer rations.
METABOLISM AND ENDOCRINOLOGY			
Univ. of Guelph	x		Circadian rhythm in plasma adrenal steroids during ovulation cycle of the hen.
Macdonald College	x		Neuroendrocrine control of ovulation.
N.S. Agr. College		x	Determination of the relative importance of factors influencing the reproductive performance of male broiler breeders used for artificial insemination.
Macdonald College		x	Selection for fertility of frozen avian sperm and evaluation of freeze damage.
Macdonald College		x	Fertility and membrane function of frozen chicken sperm.
Macdonald College		x	Glycoproteins and mucopolysaccharides. Their bioformation. Glycoprotein of cell membranes.
Macdonald College		x	Glycoproteins and mucopolysaccharides of animal tissues, isolation and glycoprotein of c.
Macdonald College		x	Influence et role des prostaglandines sur la reproduction des oiseaux domestiques.
Macdonald College		x	Avian biochemistry.
Macdonald College		x	Freezing of turkey semen.
Univ. of Guelph		x	Iodine metabolism and the transference of minerals to the oocytes and embryos.
Univ. of Guelph		x	Factors influencing the hatchability of avian eggs.
Univ. of Guelph		x	Embryological studies in chickens.
Univ. of Guelph		x	Extension and preservation of avian spermatozoa.
Univ. of Guelph		x	Thyroid metabolism in the normal chicken.
Univ. of Guelph		x	Spermatozoa competition in fertilization of chickens.
Univ. of Manitoba		x	Mineral metabolism.
Univ. of Manitoba		x	Factors affecting fertility in male fowl.
Univ. of Saskatchewan		x	Preservation of poultry germ plasma.
Univ. of Guelph		x	A comparative study of growth, postmortem metabolism and pathology in poultry muscle (chicken, turkey and duck).
Univ. of B.C.		x	Early nutrition and the reproductive capacity of broiler breeders.

TABLE 2 (continued)

Institution	Relevance Specific	General	Title
METABOLISM AND ENDOCRINOLOGY (cont'd)			
Univ. of B.C.		x	Factors in embryonic development.
Univ. of Guelph		x	The physiology and application of force-molting in poultry.
Univ. of B.C.		x	Adipose tissue development in the growing bird.
Univ. of B.C.		x	Broiler breeder hen egg-production and hatchability studies.
Univ. of B.C.		x	Calcium mobilization of chicken embryo.
Univ. of B.C.		x	Effects of early surgical and hormonal bursectomy on the thymic development of the chick embryo.
LAYER FLOCK HEALTH			
Agr. Canada	x		Studies of egg- and tissue-derived leukosis virus group specific antigen.
Univ. of Alberta	x		Effects of low glucosinolate, low erucic acid rapeseed meals on incidence of hemorrhagic liver syndrome in laying hens.
Agr. Canada		x	Studies on lymphoid leukosis in chickens.
Agr. Canada		x	Study of the response of chicken to orderly administered antigens derived from various Salmonella species.
Agr. Canada		x	Studies on the etiology, pathogenesis, epizootiology and control of Marek's disease.
Agr. Canada		x	Application of the fluorescent antibody technique to the diagnosis of some avian virus diseases.
Agr. Canada		x	Studies on lymphoid leukosis in chickens.
Agr. Canada		x	Studies on adenovirus infections in poultry.
Agr. Canada		x	Studies on the complement-fixation test for the demonstration of antibodies in the serum of chickens infected with bacterial and viral diseases.
Agr. Canada, Man.		x	Isolation and identification of E coli and E coli bacteriophage from poultry.
Agr. Canada, B.C.		x	Monitoring of migratory water fowl of the Pacific flyway for disease agents potentially pathogenic to Canadian poultry.
Ecole St. Hyacinthe		x	Le role protecteur des récepteurs H-2-Histaminergiques et B-adrenergique dans le choc anaphylactique de la poule gallus domestiques.
Univ. of Guelph		x	Diagnosis of infectious bursal disease of chickens by the immuno-perioxidase test.
Univ. of Guelph		x	Necrotic enteritis in broiler chickens.
Univ. of Guelph		x	Experimentally induced aspergillosis in chickens.
Univ. of Guelph		x	Vaccine development for prevention of bovine pasteurella pneumonia.
Univ. of Guelph		x	Etiology and pathogenesis of perosis in broiler chickens.
Univ. of Guelph		x	The pathogenetic effects of Eimeria species in domestic fowl and the immune mechanisms associated with these parasites.

TABLE 2 (continued)

Institution	Relevance Specific	Relevance General	Title
LAYER FLOCK HEALTH (cont'd)			
Univ. of Guelph		x	Drug resistance in coccidia.
Univ. of Guelph		x	Infectious tenosynovitis in broiler chickens.
Univ. of Guelph		x	Inheritance of miniature body size in turkeys.
Univ. of Manitoba		x	Salt toxicity in avian species.
Agr. Canada, N.S.		x	Acute death syndrome (ADS) or 'flip-over' disease in broilers—plane of nutrition and stress factors.
Agr. Canada, N.S.		x	Leg weakness in roasters and broilers.
Univ. of B.C.		x	Perosis in broilers.
Univ. of Sask.		x	Production as related to health of flock.
B.C. Agriculture		x	Determine effective vaccine for the control of infectious bronchitis in poultry flocks.
LAYER FLOCK MANAGEMENT			
Agr. Canada, N.S.	x		Bioeconomic evaluation of environmental factors for egg-production strains.
Agr. Canada	x		Efficiency of producing eggs and egg products.
N.S. Agric. College	x		Effect of dubbing on the performance of caged laying stock.
N.S. Agric. College	x		Effect of day-old toe clipping vs non-clipping on layer performance.
N.S. Agric. College	x		A comparison of the performance of layers managed in the conventional fashion with those given no light or feed one day per week.
Agr. Canada, B.C.	x		Restricted feeding of layers.
Agr. Canada, N.S.		x	Bioeconomic evaluation of environmental factors for meat-production strains.
Univ. of Laval		x	Valorisation des fientes de volailles.
Univ. of Guelph		x	Reduction of mortality in neo-natal turkeys by stimulated feeding.
Agr. Canada, N.S.		x	Effect of photoperiod and light intensity during the juvenile and adult stages.
Agr. Canada, N.S.		x	Dietary X photoperiod X light intensity X genotype main effects and interacting relationships with both chicken and turkey broilers.
N.B. Agriculture	x		Testing effect of light intensity on Leghorns in cages.
B.C. Agriculture		x	Short day length for production pullets.
B.C. Agriculture		x	Effects of light intensities on production pullets.
B.C. Agriculture		x	Use of parasitic wasps for fly control in poultry barns.
BIRD BEHAVIOR AND WELFARE			
Agr. Canada	x		Effect of stocking density and group size on the performance of caged White Leghorn pullets.
N.S. Agric. College	x		Force-molting of layers.
Macdonald College	x		Influence des cycles nyothemeraux et d'une courte illumination nocturne sur la ponte chez la poule pondeuse.

TABLE 2 (continued)

Institution	Relevance Specific	Relevance General	Title
BIRD BEHAVIOR AND WELFARE (cont'd)			
Agr. Canada, B.C.		x	To determine the effect of low energy in chickens and their interaction with stress factors.
N.S. Agric. College		x	Performance of broiler breeders in cages.
Univ. of Guelph		x	Sudden death syndrome in broiler chickens.
Univ. of Guelph		x	Pharmacological aspects of immediate type hypersensitivity in the domestic chicken.
Univ. of Guelph		x	Cage broiler rearing.
Univ. of Guelph		x	Control of broodiness in turkey hens.
Univ. of Guelph		x	Growing chicken broilers in cages.
Univ. of Sask.		x	Cause of acute death syndrome in broiler chickens.
B.C. Agriculture		x	Cage density studies on rearing pullets.
B.C. Agriculture		x	Effects of severe debeaking on production pullets.
EGG AND LAYER MARKETING			
Agr. Canada	x		Elucidation of genetically controlled mechanisms which influence shell quality.
Agr. Canada	x		Elucidation of factors that influence eggshell quality.
Agr. Canada, Alta.	x		A study of changes in certain egg quality traits associated with egg production obtained through application of selection procedures for this trait.
Agr. Canada	x		Forecasting model for the North American egg sector.
Agr. Canada	x		Prediction of eggshell strength under commercial conditions.
Agr. Canada	x		Poultry products processing and quality: measurement methods for eggshell strength.
Ont. Ministry of Ag. & Food	x		The egg industry in Ontario.
Alta. Agr.	x		Rhode Island Red egg-odor test.
Macdonald College	x		Functional properties of egg white protein.
Macdonald College	x		Modification of egg yolk lipids through diet and genetic selection of the hen.
Univ. of Manitoba	x		Mineral metabolism in laying hen—eggshell quality.
Univ. of Manitoba	x		Comparative factor prices and product cost in Canada and U.S. egg production.
Univ. of B.C.	x		Rheological and functional properties of egg yolks.
Univ. of Sask.	x		Comparison of genetic stocks of chickens regarding incidence of thin-shelled eggs and eggs without shell late in the laying period.
Agr. Canada, B.C.	x		Study of factors that control the decline of albumen and interior quality in shelled eggs.
N.S. Agr. College	x		Interior egg quality—the relationship between Haugh unit score and commercial grading.
Univ. of B.C.	x		Factors affecting egg yolk cholesterol.
Agr. Canada, B.C.	x		Factors affecting shell quality—ingredients.

TABLE 2 (continued)

Institution	Relevance: Specific	Relevance: General	Title
EGG AND LAYER MARKETING (cont'd)			
Agr. Canada		x	Studies on Salmonella in poultry.
Univ. of Guelph		x	Development of monitoring procedures for early detection and control of Salmonella and arizona infections in chickens and turkeys.
Univ. of Guelph		x	Factors in poultry and their products associated with specific abnormal flavor and taste.
Univ. of B.C.		x	Salmonella in British Columbia poultry.
Univ. of B.C.		x	Study of Salmonella in broiler chickens; dissemination of Salmonella during transportation.
Univ. of Guelph		x	Quality of the carcass as it may relate to the further processor and consumer.
Alta. Agr.	x		Diet supplementation with chromium and magnesium, phosphorus and salt balance etc. re egg quality.
Ont. Ministry of Agr. & Food and Univ. of Guelph	x		Increase in proportion of egg yolk with age of bird.
ENGINEERING AND HOUSING EQUIPMENT AND DESIGN			
Agr. Canada	x		Canada Plan Service poultry housing and equipment; design of poultry and egg-production facilities.
Agr. Canada		x	Winter ventilation in livestock and poultry buildings; evaluation of porous ceiling ventilation systems and thermosiphon heat exchangers.
Univ. of Guelph		x	Land disposal of liquid waste from an integrated duck rearing and eviscerating operation.
Univ. of Guelph		x	Drying of poultry manure.
N.S. Agr. College		x	Investigation of the possible benefit of using overhead air-circulating fans in floor brooding/growing facilities.
OTHER			
Agr. Canada		x	Analytical methodology of herbicides and their fate in soils, waters, plants and animals.
Univ. of Laval		x	Cycle de contamination quotidien en relation avec l'état sanitaire d'une usine approuvé—Canada.
Univ. of Guelph		x	Quality of the carcass as it may relate to the further processor and consumer.
Univ. of B.C.		x	Chemical and physical properties of food systems (meat).
Univ. of B.C.		x	Clubbed down syndrome in commercial broiler hatching eggs.
Agr. Canada, N.S.		x	Progeny testing.
Agr. Canada, N.S.		x	Care and handling of hatching eggs.
Agr. Canada, N.S.		x	Effect of transfer time on incubated eggs.
Agr. Canada, B.C.		x	The early nutrition and management of the chick.

because they may have indirect relevance for egg producers. Within these guidelines we have tended to include as many research projects as possible from the sources used.

The subject of research into egg production and marketing has been divided into nine aspects for the purpose of the Ottawa conference. Table 3 lists the aspects of egg production and marketing research, together with the numbers of specific and general research projects which are currently being conducted in each aspect. Some projects could have been categorized in more than one aspect. In these cases they were categorized according to the aspect that appeared to be closest to producer interests. For example, the project to elucidate genetically controlled mechanisms which influence shell quality is found in the section on egg and layer marketing, although it would have been possible to classify it under genetics.

TABLE 3. Current Research Projects in Egg Production and Marketing, by Aspect

Aspect	Relevance: Specific	General
Genetics and breeding	4	4
Nutrition	5	50
Metabolism and endocrinology	2	25
Layer flock health	2	25
Layer flock management	7	8
Bird behavior and welfare	3	10
Egg and layer marketing	20	6
Engineering and housing equipment and design	1	4
Other	0	9
Total	44	141

Table 3 shows that among topics specifically related to egg production and marketing, the egg and layer marketing grouping has the most projects (20 out of 44).

The 20 projects concerned with egg and layer marketing (Table 4) are widely scattered among government and universities. Shell quality, interior egg quality and Salmonella are the aspects of marketing currently being most frequently researched.

Among the research projects of general relevance there is a strong emphasis on nutrition (50 projects out of 141). Agriculture Canada, the universities of British Columbia, Guelph, Manitoba, Alberta and Toronto are active and so is the Alberta Department of Agriculture. Project titles (Table 2) indicate that about half of these projects are concerned with the evaluation of feedstuffs (including rapeseed, wheat screenings, squid meal). Several more relate generally to poultry requirements and others specifically to energy and protein requirements in poultry. A small number of projects (about six) are concerned with minerals, vitamins and antibiotics, thyroid requirements and hormonal factors.

There are 25 projects related to metabolism and endocrinology being researched. There are another 25 projects relating generally to layer flock health and 10 projects of general relevance to bird behavior and welfare.

Projects relating to metabolism and endocrinology are listed for the universities of Guelph, British Columbia, Manitoba and Saskatchewan, Macdonald College and the Nova Scotia Agricultural College. Predominant are studies on aspects of reproductive physiology such as ovulation, artificial insemination, the freezing of sperm, hatchability of eggs and embryology.

Studies on layer flock health are being carried out chiefly by Agriculture Canada and the University of Guelph, with several other universities and the British Columbia Ministry of Agriculture also being

TABLE 4. Egg Production and Marketing Research Projects: By Aspect and Institution

Research	Genetics & breeding		Nutrition		Metabolism & endocrinology		Layer flock health		Layer flock mgmt		Bird behavior & welfare		Egg & layer mkting		Engineering & housing equip. & design		Other		Total	
institution	Spec	Gen	Spec	Gen	Spec	Gen	Spec	Gen	Spec	Gen	Spec	Gen	Spec	Gen	Spec	Gen	Spec	Gen	Spec	Gen
Government																				
Agric Canada	3	1	1	18			1	11	3	3	1	1	8	1	1	1		5	18	41
B C Agric								1		3		2							–	6
Alberta Agric				2									2						2	2
Ont Agric													2						2	–
Oue Agric	1																		1	–
N B Agric									1										1	–
																	Sub-total		24	49
Universities & colleges																				
N S Agric College						1			3		1	1	1			1			5	3
MacDonald College		1			1	7					1		2						4	8
Laval										1								1	–	2
Ecole St Hyacinthe								1										–	1	
Guelph		1	4	5	1	8		9		1		5		3		2		1	5	35
Toronto				1									2						–	1
Manitoba				9		2		1					2						2	12
Saskatchewan						1		1				1	1						1	3
Alberta				6			1												1	6
British Columbia		1		9		6		1					2	2				2 2	21	
																	Sub-total		20	92
Total	4	4	5	50	2	25	2	25	7	8	3	10	20	6	1	4	0	9	44	141

active. Over half of the projects relate to the occurrence and prevention of specific diseases, e.g., hemorrhagic liver syndrome in laying hens, lymphoid leukosis, bursal disease, salt toxicity and acute death syndrome ('flip-over' disease).

Research projects on bird behavior and welfare are located chiefly at the University of Guelph and the British Columbia Ministry of Agriculture. They relate to the performance of caged birds, acute death syndrome, force-molting, debeaking and detoeing, and to the provision of a period of light during the night. It is apparent that there is an overlap between bird behavior and welfare, layer flock health and layer flock management. Some projects could be categorized in more than one group.

In addition to the research by universities and government so far listed, research is carried out by private industry. This is being done by primary breeders, major feed suppliers, pharmaceutical/biological companies and one or more producer cooperatives. There is no central source of information on the research being carried out by the private sector. We are informed that "each . . . conducts their own research independently of the others. It is . . . a very competitive business and the research results are considered to be proprietory information." Producers should be alert to the fact that industry's research may sometimes have different objectives from the producer's concept.

In general, industrial research is practical in nature, examining the application of the products sold. Major feed suppliers study the nutritional value of feedstuffs with respect to egg production, layer health, shell quality and egg size.

The Co-operative Federee de Quebec collaborates with other cooperatives in North America in an organization called the 'Co-operative Research Farms' (CRF). CRF operates a research farm for each species, and all cooperatives share research costs and data. There is one CRF farm for egg layers. This farm conducts research on a wide-range of topics, including evaluation of every commercial strain of layers available, pullet programs, molting programs, mineral and amino acid requirements, nutritional quality of feedstuffs and egg quality. A sampling of CRF's recent research includes:

Nutrition—methionine-sparing effect of sulfate (this effect is not found in practical diets)
—phosphorus requirements of layers
—protein levels vs amino acid levels
—effect of physical form of the diet
—effect of salt in layer diets
—rapeseed meal in commercial layer diets
—amino acid requirements
—vitamin fortification levels
—effect of antibiotics inlayer diets
—energy and physical form of layer diets

Layer flock management—molting programs (low calcium, high zinc, low sodium)

Egg and layer marketing—effect of feed additives on shell and interior egg quality

Bird behavior and welfare—cage rearing of pullets; effect of bird densities

The research of the Co-operative Research Farms is described as practical and applied, rather than basic.

Over the past few decades, according to Guenter (1979), the industry has achieved high levels of performance in both meat and egg production. Research in genetics, nutrition and management have all contributed to this. Such dramatic changes in performance levels are not expected to occur in the future; however, the progress that will be made in the industry over the next 10 years is dependent on the progress made in research today.

Guenter also stated that research on egg production and marketing is financed through the following:

Agriculture Canada
National Research Council
Provincial Departments of Agriculture
Rapeseed Utilization Assistance Program (Federal)
Department of Industry, Trade and Commerce
Marketing Boards
University grants
Relatively limited support from industry

Future Research Priorities

The following objectives are suggested for research into egg production and marketing:

- To reduce costs.
- To maintain specific quality standards.
- To produce sufficient volume to meet anticipated market demand.
- To maintain the health of poultry.
- To maintain the ecological balance.

Table 18 summarizes the research recommendations made by the 12 scientists who contributed to the section on the assessment of research knowledge and future priorities. The summaries are grouped according to the nine aspects shown in Table 3.

An attempt has also been made to classify the research recommendations in terms of priority (high, medium and low), and the number of years required to achieve useful results. Setting priorities for research topics is difficult. Nevertheless, the important aim of the conference was not only to identify areas for research, but to establish priorities.

Professor Guenter in his paper has stated:

> As the level of performance in the poultry industry continues to develop, the various constraints in the production system change in importance, and the research

should reflect this. The need to improve eggshell quality is an urgent economic problem . . . We need to understand and develop better breeding techniques, improved feeding systems and energy- and labor-saving management techniques. We must find ways of making best use of Canadian feedstuffs such as rye and rapeseed meal. Most efficient use of lighting and housing systems for both eggs and meat stocks under Canadian conditions must be developed. Better programs for disease prevention and control are required, especially for areas of extremely high density of poultry. Product development requires attention. Salmonella in poultry products appears to be another serious problem.

In Ontario, both the Ontario Poultry Council (composed of persons in the industry) and the Ontario Poultry Research Committee, (which is a committee of the Ontario Agricultural Services Coordinating Committee) have discussed and examined research needs in egg production.

The Ontario Poultry Council Research Committee in October, 1978 listed 10 research priorities. Part of this list is presented below. However, the first two items of the committee's list, namely new egg products and increased consumption of eggs, have been excluded here as being outside the scope of this conference.

Energy conservation

- Need more work on intermittent and shorter-day programs for laying hens.
- Develop feeding systems that conserve energy.
- What is the ideal temperature and humidity for storing eggs, keeping energy conservation in mind?
- Where would it be practical to use solar heat in the poultry industry?

Use of by-products

- Disposal of poultry manure is still a major problem on many egg farms. More uses should be explored for eggshells, hatchery waste and spent hens.
- We would eliminate a huge waste in our industry if we could tell which fertile eggs were going to hatch male and female chicks, since we destroy all males at one-day-old.

Nutrition

- Feed efficiency must keep improving to compete with other food products in agriculture.
- What role does nutrition play in interior quality?
- How can we improve shell quality at the end of the lay?
- Consumers feel they are getting more cracked eggs in the stores that they did a few years ago.
- Some good research has been done in Guelph on split-diet feeding. Can we find a Canadian cage manufacturer to work with the Engineering Department of Guelph University or Agriculture Canada to develop a practical feeder for use in the industry?
- More research is needed on the use of rapeseed meal in poultry feeds so that egg producers can be convinced it is a safe product. We should not have to depend so much on imported soybean meal.

Diseases

- Do we have 'egg-drop' syndrome in Ontario?

Cage designs and bird welfare

- We must continue to be aware that the Humane Society and other groups do not fully approve of housing birds in cages. By making birds more comfortable with less competition for feed and water (e.g., the reverse cage), we may also make egg production more profitable. This whole area needs more attention.

Shell quality

- From the consumer's viewpoint, this is a serious problem. Too many cracks could lead to lower consumption.
- Part of the solution is education from producer to chain store (e.g., selling hens earlier, equipment maintenance, etc.).
- Are we washing eggs properly?
- How important is egg-holding temperature?

Cholesterol and heart disease

- This is an area which will likely have to be explored by egg boards and CEMA to see if we can dispel the cholesterol myth during the next generation.

Genetic research

- Most producer and industry people do not see a real need for government and universities to put much importance on this area since commercial breeders seem to be improving the genetics of laying strains fairly steadily.

The Ontario Poultry Research Committee, reporting to the Ontario Animal Research Committee in January, 1979 listed 28 research proposals of which 18 are of direct or indirect importance to egg producers. These are listed in Table 5.

The Ontario Poultry Research Committee has summarized part of egg production research needs as follows:

> It is increasingly evident that a multi-disciplinary approach is required for the solution of many current problems.
>
> Studies of egg quality, both shell and interior, require continued support... There are several disease conditions which require attention. Salmonella infection of poultry and contamination of poultry products continue to damage the industry's reputation. Adenovirus infections, infectious bronchitis, lymphoid leukosis, coccidiosis, hemorrhagic enteritis, sudden death syndrome all require further investigation. Leg weakness is a cause of large economic losses and must be tackled in a coordinated manner. There is a need for surveys to quantify the economic impacts of disease and thus provide basic information for establishing research priorities.
>
> There is evidence that preservatives in wood shavings are hazardous to poultry. One suspected effect is immunosuppression which may initiate one of several secondary disease outbreaks. Work is required to study the hazards associated with the use of shavings and to search for alternative foı ms of litter.
>
> As genetic and management changes occur it is reasonable to anticipate alterations in nutrient requirements. This is a continuing area for research as is the related one of measuring nutrients availabilities in feedingstuffs...
>
> Ways must be found to reduce embryo deaths in chicken and turkey eggs. Work on male reproduction is required, particularly in the areas of semen storage and extension.
>
> In the area of poultry management, attention should be directed to energy conservation and the development of more-effective lighting programs. The welfare of birds requires continued study if anticipated prohibitive regulations are to be avoided. Continued work on bird behavior has the potential for significant economic gains.
>
> Genetic research is important to improved productivity, control of product quality and the prevention of disease. It is a key part of the multidisciplinary approach which must be used in many research projects.

All provincial departments of agriculture, through their deputy ministers or poultry specialists, have responded to the enquiry as to research priorities in egg production. We are grateful for this input to the conference and we list their stated priority needs below.

Newfoundland—Research needs include:

- Continued efforts to seek improved efficiencies in egg production and feed utilization.
- Continued emphasis on lighting requirements to maximize both egg production and energy conservation.
- Research on waste utilization. In Newfoundland, with a poor soil base, research is still needed on practical methods to store and process waste, with consideration given to labor efficiency in waste-handling methods.

Prince Edward Island—Areas which require additional research include:

- Better-formulated rations for more-efficient production.
- Rations specifically designed to meet the special requirements of each particular strain of bird available to Canadian producers.
- Research into better and more-reliable ways to maintain shell quality through the full laying period.
- Research is required into maintaining and improving quality in available laying strains.

Nova Scotia—The chief priorities for research are now in the areas of:

- Egg quality (shell strength).
- Disposal of fowl.

New Brunswick—From a practical standpoint, research projects that will improve the economics of production should receive priority. The long-term results will be the continuation of an efficient industry. Areas for research include:

- It is considered that the industry still does not have a suitable method of determining daily feed consumption and hence cannot correctly meet the nutritional requirements during the laying cycle. This is evident in the number of mature fowl going to market with excessive body fat.

TABLE 5. Research Proposals Relevant to Egg Production*

Proposal number	Topic	Priority	Recommendation	Also recommended by the OARC to the OASCC*
2	To continue research into ways of reducing Salmonella contamination of poultry and poultry products.	High	Stimulate a small increase in research	x
4	To support research on adenovirus infections in poultry (including adenovirus 127, and infectious bronchitis of poultry).	High	Support an increase in research	x
5	To initiate research on poultry litter by investigating the hazards associated with the use of woodshavings and by identifying and evaluating possible substitutes. A simple test for polychlorophenols in shavings is also required.	High	Initiate research on poultry litter	
6	To study the economic and technical merits of a poultry extension service within OMAF.	High	Initiate an appropriate study	x
20	To support research relative to the development, conservation and evaluation of new and existing sources of energy.	High	Increase research from current level	
9	To maintain and support research on the evaluation of poultry feedingstuff	Medium	Maintain at current level	
10	To increase research into the nutrient requirements of all classes of commercial poultry.	Medium	Continue at present level	
11	To continue research into ways of eliminating lymphoid leukosis virus from poultry flocks.	Medium	Continue at present level	
12	To continue research on factors affecting eggshell quality and interior quality.	Medium	Continue at present level	
15	To continue research on coccidia resistance to drugs in chickens and turkeys.	Medium	Continue at current level	
16	To initiate research on the embryology and hatchability of chicken and turkey eggs.	Medium	Initiate research on the mortality of avian embryos	
18	To initiate research on male reproduction and semen storage.	Medium	Increase research on male reproduction	
19	To develop production technologies which provide higher standards of animal welfare.	Medium	Stimulate a small increase in research and encourage those working in the management and environment areas to pay additional attention to bird welfare	
21	To initiate behavioral research related to better utilization of production potentials of poultry.	Medium	Increase the level of research	
23	To continue research on the genetic techniques for the improvement of egg-producing stocks of chickens.	Low	Maintain at current level	

TABLE 5. (continued)

Proposal number	Topic	Priority	Recommendation	Also recommended by the OARC to the OASCC*
24	To initiate a survey of 'normal' mortality in commercial poultry flocks.	Low	Encourage the collection and tabulation of mortality data by industry as well as research institutions	
26	To investigate the effects of light on all classes of poultry and to devise optimal lighting programs.	Low	Continue at current level	
27	To increase research on the cause and prevention of sudden death syndrome (heart attacks or 'flips') in broiler chickens.	Low	Continue at current level	

* Taken from the Report of the Ontario Poultry Research Committee to the Ontario Animal Research Committee, January 1979. The Ontario Animal Research Committee in its 1978-79 report to the Ontario Agricultural Services Co-ordinating Committee also made a proposal "to assess existing systems and possibly develop systems for monitoring drugs and residues in foods from animals".

- Eggshell strength is another important area for research by the industry.
- Additional research is needed on the avian leukosis complex. The major losses during the growing and laying period are due to Marek's disease and leukosis.
- Research projects aimed at reducing the feed energy requirements of poultry from one-day-old to maturity.

Quebec—The main spheres of research activity that the Quebec Council for Livestock Production feels should have priority are:

- Setting feed standards, with reference to conditions in Quebec, for flocks, for multiplication, meat production and egg production.
- Organization and use of insemination (with frozen semen) for breeders of grill chickens and turkeys (and of layer hens). The parentheses mean that the agricultural research stations have identified these as taking priority.
- In the area of health, viral infections, mycotoxins and Salmonella are diseases that have been identified as first-rank priorities for research.
- Disposal and/or use of hatching wastes (non-fertile eggs, embryos, destroyed chicks, and eggshells) are a problem for hatcheries. The Quebec Council for Livestock Production thinks that synthesizing the knowledge gained elsewhere and diffusing it might help to bring an efficient solution to this problem.

Ontario—Relevant priorities for poultry research, as recommended by the Animal Research Committee in February, 1979, are:

- To continue research into ways of reducing Salmonella contamination of poultry and poultry products.
- To support research on adenovirus infections in poultry (including adenovirus 127), and infectious bronchitis of poultry.

Manitoba—Chief research priorities, as outlined by the local poultry subcommittee of M.A.S.C.C., are:

- Egg quality, both interior and exterior.
- Continued research on alternative feedstuffs and on ways of improving digestability and utilization.

Saskatchewan—Research areas include:

- Utilization of Saskatchewan-grown products in poultry rations.
- Bringing the provincial poultry performance up to national level.

Alberta—Main priorities are:

- Use of various varieties of rapeseed meal in starter, growing and layer rations.

Future work will likely include the substitution of coarse grains (barley, hull-less oats) in poultry rations.

- Egg quality improvement. Current and proposed work in this area will involve diet supplementation with chromium and magnesium, phosphorus and salt balance.

British Columbia—Some of the main priorities in egg production that research scientists should devote their research to are:

- Endeavor to develop cheaper feed sources. More research is required in the use of cheaper grains such as barley, and in the development of cheaper protein concentrates to offset the higher costs of energy sources in feed ingredients.
- Studies on protein requirements for layers in phase feeding, starting with 18% or 16% protein ration and then dropping to as low as a 14% protein ration as the birds near the end of their laying period. This could be correlated with studies on using lower-protein rations for growing pullets.
- More research on feeding beef and replacement heifer cattle on dried poultry manure. This manure is available from deep-pit (high-rise) laying barns using drying fans over the manure. At today's prices it costs approximately 10¢ per bird per year to operate these drying fans, and feeding this manure to cattle could bring some returns to the egg producer. Pressure should be applied to Agriculture Canada and to Health and Welfare Canada to allow such studies to be conducted on commercial herds.
- Where do we stand as to the use and availability of 'Triticale'?
- An important research project would be that of studying the 'utilization of feed ingredients as they are delivered to the feedmill'. When feed wheat is delivered to a feed mill, it has not been cleaned and goes directly into the feed-mixing process. The question asked here is: What is the end result in energy and protein? This may not be in accordance with the product label. It would benefit the feed manufacturers and the producers if both were assured that the input ingredients were actually what they thought they were. It would help nutritionists in the compilation of feeding rations.

In addition, Professor Earl C. Hunt of the University of Guelph, who has been visiting people in the poultry industry of British Columbia to identify problems areas, has kindly submitted the following:

> Many questions lend themselves to scientific research, for example, reasons behind weak eggshells or brittle bones, breast blisters and weak legs in meat birds. On the other hand, the effect of cage design and the selection of litter materials on the above receive little attention. More research needs to be conducted on light intensity, air movement within the pen, and the best type of waterer to use for each specific age group, etc. In summary, the physical aspects of management elicited the most questions.
>
> Nutritionists work constantly at formulating the best rations for specific purposes. We know how mash versus crumbles versus pellets work in aiding production of eggs or meat. What is not known is which works best in a cage situation with various densities of birds.

From the Co-operative Federee de Quebec we have received two suggestions for the further development of two areas and we quote:

> Generally speaking, it is our opinion that two of the greatest areas for potentially improving the economic returns of egg producers in Quebec (and elsewhere) could come from further developing two features that are current knowledge.
>
> The first would be to encourage acceptance of darker yolks by the retailer. In the Quebec market, Steinberg buyers restrict themselves to somewhat pale-colored yolks. This requirement restricts the use of corn in layer diets, consequently placing an economic penalty on the cost of production. Corn is generally restricted to a maximum of about 15%. It is well known that darker-colored yolks are readily acceptable to the consumer.
>
> The second area would be to encourage the concept of feeding amino acids to laying hens rather than the concept of feeding total protein.
>
> It is current knowledge that laying rations balanced to provide optimum consumption of amino acids are more economical than rations formulated to provide fixed levels of total protein intake. It is apparent to our organization at least, that the Quebec market has a tendency to require excessive levels of protein for laying hens. Such diets are uneconomical and consequently reduce the economic returns of the egg producer.

Sources
(Current research, and future research priorities)

Canadian Agricultural Research Council: Inventory of Canadian Agricultural Research,

November 1978 or later.

W. Guenter: Poultry Research—Who's Doing It—and Why?, Dept. of Animal Science, University of Manitoba, presented to the Forty-first Convention of the Canadian Hatchery Federation, August 30, 1978.

Letters from Deputy Ministers of Agriculture or Poultry Specialists of all Provincial Departments of Agriculture.

Ontario Ministry of Agriculture and Food: News releases, Older Hens Have Bright Future, June 12, 1978, 78-60F.

Letters from industry: Canadian Feed Industry Association
Canada Packers Ltd.
Co-opérative Fédérée de Québec
Shaver Poultry Breeding Farms Ltd.

Letters from Professor Earl C. Hunt, Coordinator of Extension, Dept. of Animal and Poultry Science, University of Guelph.

Research and Related Industry Priorities as discussed by the Special Egg Industry Committee (of the Ontario Poultry Council) October 18, 1978.

Communication from Mr. Craig Hunter Jr., Chairman of the Research Committee of the Ontario Poultry Council.

Report of Sabbatical Study by Earl C. Hunt, Dept. of Animal and Poultry Science, University of Guelph.

Report of the Ontario Poultry Research Committee to the Ontario Animal Research Committee, January 1979.

1978-79 Report of the Ontario Animal Research Committee to the Ontario Agricultural Services Co-ordinating Committee.

Action taken on Provincial-Regional Agricultural Services Coordinating Committees and Canada Committee R & D Recommendations to CASCC 1977.

Canadian Egg Marketing Agency: Gallup Omnibus Study conducted for Canadian Egg Marketing Agency, December 1978.

EXTENSION WORK IN EGG PRODUCTION

Extension work in egg production has generally been performed by provincial departments of agriculture, although private industry and universities are also active in varying degrees. All provincial deputy ministers of agriculture have responded to our request for information on who does the extension work and on the chief problems encountered by the extension workers. The participants at the conference acknowledge this cooperation. As the structuring of extension work is chiefly on a provincial basis, and as egg producers themselves are likely to be provincially oriented as regards extension work or contacts, it was decided to consider extension work in each province, based on the responses from the provinces.

British Columbia

The Poultry Branch in British Columbia has one specific specialist who is responsible for the extension programs for the egg producers in the province. He works under the direct supervision of the head of the branch and consults with the Provincial Veterinary Laboratory and related agribusiness and poultry associations. Personal contact and farm calls with the egg producers are very important aspects of the position, together with liaison with the Egg Marketing Board.

The poultry extension specialist is also an applied research scientist. Research is carried out at the Poultry Branch Research Farm in Abbotsford. Studies are conducted on feed trials, strain evaluation and cage management systems. Projects presently under way (1979) include:

- Cage density studies on rearing pullets.
- Short day length for production pullets.
- Effects of severe debeaking on production pullets.
- Effects of light intensities on production pullets.
- Use of parasitic wasps for fly control in poultry barns.

In addition to research, the specialist handles farm management programs through Canfarm; comparative cost analysis data; new poultry house design, and ventilation systems. Disease control programs are carried out in consultation with the provincial veterinarian and the head of the Poultry Branch. In addition, new means of handling poultry manure in deep-pit (high-rise) laying houses have been developed in British Columbia. The specialist must have extensive knowledge and experience in

his field of specialty and it is essential for him to know about the latest research and technological advances in the industry so that this information can be disseminated to primary egg producers.

Alberta

Extension work with egg producers is carried out through five regional offices in the province. Poultry specialists call on these producers on a regular basis. The main thrust at present is towards improvement in egg quality. Increasing production efficiency is, of course, an on-going extension effort. In addition, a number of seminars and educational conferences are held each year for the benefit of egg producers as well as other segments of the poultry industry.

Alberta Agriculture has a farm for applied poultry research. The research priorities are determined in consultation with producers, allied industry, extension workers and university researchers and are related to problems immediately facing the poultry industry. Final decision is made by a select research committee.

Saskatchewan

Extension work with egg producers is undertaken by the poultry specialist and by representatives of various commercial feed, hatchery and product distributors. There is also input from the University of Saskatchewan and from the Western College of Veterinary Medicine.

At the present time, the department is dealing with problems in small flocks. There is as much work in trying to assist people in getting good equipment, sound financial planning and sound business practices as there is in feeding, management and disease prevention.

Manitoba

The extension work for egg producers is performed by:

—Governments (federal and provincial)
—Feed and industry personnel
—Hatchery personnel
—Drug suppliers
—Equipment manufacturers and distributors

The chief problems of extension are basically those of trying to get acceptance and understanding of known technology. The areas of this technology that can be highlighted change from time to time and place to place, but the main problem is how to convince people that doing things by the book really pays off.

Ontario

Extension work for egg production is done by various groups, namely:

—Extension coordinators for faculty members in the Department of Animal and Poultry Science and the Ontario Veterinary College (University of Guelph), operating under contract with the Ontario Ministry of Agriculture and Food.
—Researchers: primarily from the University of Guelph.
—Extension specialists of Ontario Ministry of Agriculture and Food (OMAF); farm management; engineering and crop specialists, and veterinarians.
—Poultry specialists with feed companies.
—Agricultural specialists with banks.

The chief problems presently dealt with by extension workers include:

- Areas of management, including ventilation, lighting and cage design.
- Aspects of nutrition, including feed consistency, i.e., mash, crumble or pellet; protein content; salt in the diet, particularly in hot weather, and calcium content.

In Ontario, with the biggest egg-production industry of any province, extension work may be in a period of change. The University of Guelph is performing less extension work than formerly. Veterinarians, and feed, drug and hatchery salesmen are active. The Ontario Egg Producers Marketing Board is in process of hiring its first full-time poultry specialist for extension work.

In nutrition, producers are concerned with the feeding of a pullet that matures earlier (at 20 weeks instead of 24 weeks). Cracks and egg breakages are a problem at all stages, namely: poultry houses, grading stations and retail stores.

Quebec

Extension services for Quebec producers are provided by the Quebec Department of Agriculture, by producer federations, and by private enterprise. It would be interesting to establish the number of those involved in each of these sectors.

New Brunswick

Extension work in New Brunswick is conducted by the staff of the agriculture department (poultry specialists, engineers, veterinarians, economists), by private veterinarians and by various commercial companies.

There are no major industry-wide problems at the present time. However, there are individual problems with mortality from Marek's disease and leukosis, and from time to time, nutritional problems

related to feed milling problems. Other problems relating to possible mold toxins, vitamin deficiencies, feed separation, etc., have not been satisfactorily answered due to difficulties in obtaining an analysis.

Most of the producers in the egg-production industry are experienced, and hence are very knowledgeable. They have contacts with producers, equipment manufacturers, etc., throughout Canada and the U.S.A.

Nova Scotia

One of the major grading stations in Nova Scotia does the extension work and provides a very useful service to its shippers by pointing out some of the weaknesses in their system in comparison with the other shippers. There are two professionals, and by 1980 a third professional will be on hand to work and provide the necessary services to the industry.

Prince Edward Island

Extension work for egg producers in P.E.I. is carried out mainly by:

—Department of Agriculture and Forestry (poultry fieldman)
—Egg Marketing Board (manager)
—Feed and equipment sales personnel
—Chicken hatchery field staff
—Poultry specialists from the Research Station, Kentville, Nova Scotia

The chief problems encountered by extension workers include:

- Feeding and management problems.
- Disease problems.
- Building construction, ventilation and equipment problems.

Newfoundland

Extension work is done primarily by a poultry specialist but, during the period when this position is vacant, the provincial department does not provide adequate extension. The general agricultural representatives are not able to do this effectively. The only other personnel providing extension services are feed companies and the Egg Marketing Board. Very briefly, the major problems are waste management and disposal, and high production costs, especially of feed.

Genetics and Breeding

A report by R. S. Gowe, Animal Research Institute, Agriculture Canada, Ottawa.

Genetics in Layer Production Efficiency

It could be stated that the genes of the laying hen are involved in all aspects of production and the quality of the eggs to be marketed. The following table shows the involvement of genetic variation in all the significant traits of the egg-production bird and in all the significant environmental factors, because genes can only act within an environment in which they can be expressed.

Production of low-cost, high-quality eggs depends on the following components:	These components are influenced by genetic variation in:
Reproductive efficiency of the parents	Fertility, hatchability
Nutritional regime	Nutritional requirements for rearing and adult periods
Physical environment	Response to light, temperature, housing type, management procedures and other environmental factors
Livability	General and specific disease resistance, response to vaccination
Behavior	Behavioral patterns of young and adults
Number and quality of eggs produced	Sexual maturity, egg production, egg size, interior egg quality, exterior egg quality
Spent carcass value	Carcass weight, fatness and condition

The table shows that genes control all the components that are concerned with egg production. The genes that determine the size or number of eggs a bird will lay cannot operate without a complete and adequate physical and nutritional environment and sometimes these non-genetic components are the limiting factors.

The progress achieved in breeding for high and more-efficient egg production over the last 20-30 years is well known. The laying hen today produces about 250 eggs at a cost of 1.7 k of feed per dozen eggs, whereas 25 years ago the comparable figures were about 180 eggs and 3.0 kg of feed per dozen. Nevertheless, further progress in production efficiency is desirable and quite possible. The improvement from present-day levels of production will be more difficult and will require more-sophisticated and balanced approaches to concurrently improving the genetics of the commercial bird while improving the physical and nutritional environment and management procedures.

The dramatic increase in the level and efficiency of egg production has, unfortunately, not been accompanied by a parallel increase in the understanding of the detailed requirements of the modern hen. It is true that the general environmental requirements, including the nutrition of the hen, are known. However, the fine tuning of these requirements to the demands of particular genetic stocks and feeds available is lacking. It is well known that the response of particular genotypes to a particular nutritional or light regime or disease exposure often varies so widely that the production efficiency of stocks of the bottom end of such variation can be commercially unacceptable. Thus the problem of genotype environment interactions requires interdisciplinary research.

Genotype-Environment Interaction

Although genes are important in almost all aspects of the life of the egg-production bird, they cannot act in the abstract; nor can any of the other

factors, such as the nutritional or the lighting regime, act without the genes. The performance achieved from any population of birds depends on the genetic makeup of that population, the feed and the environment. These are areas where there are known problems and where the interrelationship is constantly evolving. Unfortunately, many producers as well as some scientists fail to recognize the importance of genotype-environment interactions and are often misled both to the cause of problems in populations, and to potential solutions to these problems. It is necessary to consider both the genetic factors and the environmental and nutritional factors involved in the performance of a population of birds.

Another illustration of the importance of interactions is recent work which has shown that there are large differences in the effectiveness of Marek's disease vaccine in different strains of chickens. This difference is related to the degree of genetic resistance to Marek's disease in these strains. The more-resistant strains produced more eggs than the less-resistant strains after all strains were vaccinated and exposed to normal industrial conditions. The strains with the greatest resistance were protected to a much higher degree by a combination of their genetic resistance and vaccination than were the strains with lower genetic resistance. Without exposure to Marek's disease these genetic differences would not have been seen.

Need for Research

Often it is not fully appreciated that genetic gains, once obtained, are usually permanent and cumulative. Even though changes in each generation are generally small, the cumulative effects can be very large. For example, at the Animal Research Institute, mean egg production has been improved in some experimental selected stocks by up to 80 eggs per hen on a hen-housed basis over the last 20 years. This was achieved while also increasing livability and egg size, and improving interior egg quality. Although this is only an increase of about 4 eggs per bird per generation (year), these gains are permanent and accumulative so that the 80 eggs are now a permanent part of the high-performance potential of the highly selected lines. Poultry breeding concerns are, for the most part, responsible for this type of continued improvement of stocks of chickens to be used in the production of the commercial bird. In general, commercial breeding companies have put very little effort into the basic aspects of breeding, such as studying new techniques and procedures for improving their selection programs. Commercial concerns depend heavily on research institutions and universities to carry out this work. Therefore, there is a high-priority need for this methodology research to be done at institutions while the actual developmental work on the commercial stocks remains with the commercial breeding companies.

Because poultry breeding is international, with stocks developed in Canada, England, Europe, U.S.A. all being widely sold in Canada, the number of breeding concerns is quite small in any one country. However, it is vital for matters of balance of trade and for the long-range protection of the poultry industry in Canada that some breeding of egg stocks as well as turkey and broiler stocks remain centered in Canada.

Beyond economic and trade considerations, there are good biological reasons why some of the poultry breeding should remain in Canada. Our climate and markets are such that we need to be assured that at least some of the birds that we use in our egg-production industry are bred under the nutritional and housing conditions of Canada, as well as under the management regimes that are best for our climatic conditions. We never know when a management, housing or feeding regime will be developed in a foreign country that cannot be applied in Canada. Stocks developed under such regimes may not perform well under Canadian conditions. It is well known that stocks gradually adapt genetically to particular regimes. The process is slow and may not be noted for a few years, but if we were to lose all our breeding populations and developmental breeding work from this country, in the long run it could have very serious adverse influences on the industry and its efficiency.

It is also important that there are several sources of breeding stock available to the industry to protect it against the possibility of disease or other conditions that would seriously set back the performance of birds with common genes (genome) if that genome turned out to be highly susceptible to disease or unable to perform under that environment. A few years ago, plant scientists and corn producers became very concerned about this possibility when a large part of the American corn crop was destroyed by a disease that affected one widely grown corn variety more than other varieties. We may be approaching this type of 'genetic vulnerability' in our poultry stocks and we need ways to protect ourselves.

To be in a position to assist Canadian poultry breeders with new information on poultry-breeding technology and methodology, it is necessary to have ongoing research programs and selection studies dealing with the high-priority problems of the industry. The largest poultry-breeding concerns do very little except developmental work, therefore it is important to have skilled and trained scientists in the country so that commercial breeders can take advantage of new technology and also to ensure that research is conducted on problems of greatest concern to the poultry-breeding industry and its customers, the egg farmers.

Since any poultry breeding or selection study is long-term, and we can only achieve one generation

a year (perhaps less if selection is based on full-year records), and because a selection study usually will not be very productive and conclusive until at least four or five generations are completed, it is clear that very little research of a meaningful nature can be done without several years' work.

Many of the most urgent problems of the breeding industry are concerned with the specific selection problems of strains of birds that have been under selection for a great many years, and where it is now difficult and complex for geneticists to make additional improvements. The problem is to determine how this can be done effectively without unbalancing the performance of the bird. The breeder must be concerned about a complex of commercially needed traits in the highly specialized strains that are used by primary breeders to produce commercial stocks.

The point of this discussion is that the most effective support for breeding research is support that is long-term—it takes time to develop specialized stocks for the research, and it takes time to answer the specific problems confronting the industry.

However, it should be clearly understood that once special stocks are developed and characterized by a research geneticist, they are a very valuable resource and form valuable base materials for examining specific breeding problems. These stocks are of particular importance in studying problems of nutritional, environmental and genetical interactions, and also for determining whether a specific problem requires a mainly genetical solution or a nutritional solution, or alternatively, a basic physiological solution. The problem may be a disease which can only be resolved by developing a vaccine or eliminating the pathogen. The solution very often will require an approach involving a combination of scientific disciplines, and the specialized, genetically characterized stocks are very valuable in making these determinations. Thus research on breeding and genetics is very important, but it needs to be of medium—and long-term duration even when dealing with problems with the highest practical priority.

There is one area of breeding research of a short- to medium-term nature. This is the study of genotype by environment interactions in the broadest sense. Canadian poultry geneticists should spend a significant portion of their research efforts investigating the differential response of genotypes (various genetic stocks) to nutritional and management regimes, and to various disease conditions. However, meaningful research on genotype-environment interactions is only possible when suitable, genetically defined stocks are used in this work.

The poultry-breeding and service industries require highly skilled professionals to work with industry people and to carry out research and commercial breeding programs. Financial support is necessary for the long-term projects that breeding research demands, in order to have skilled people trained in poultry breeding and genetics. If the ability to train people in poultry breeding and genetics to the Ph.D level is lost, we will gradually lose the research capability of this country. The poultry-breeding concerns will then move to a location where they can obtain trained people and where they have ready access to research institutions whose staff are active, supportive and up-to-date. Therefore, this is a very fundamental and practical reason why egg producers should be very concerned about maintaining a few centers of excellence in poultry breeding and genetics research in this country so that the poultry-breeding industry can be encouraged to remain viable and to stay in this country. This will in turn protect the long-term interests of the Canadian economy and the long-term interests of the Canadian egg producer by ensuring that he will always have birds that are satisfactory for his environment (including type of feed used and housing).

High-priority Areas for Research

Research must continue on methods for improving selection techniques. This work is long-term and costly because large numbers of birds must be maintained through a complete laying cycle, many traits must be measured and the data extensively analyzed, using computers. Priority must be placed on multitrait selection studies involving the number of traits necessary for the high production of quality eggs. The problem is to maximize rate of progress in strains (to be used for straincrossing) for traits that are in some cases genetically negatively related (e.g., eggshell quality and egg number) and in traits for which an intermediate level is desirable (e.g., egg size).

Emphasis must be placed on the development of multi-trait selection programs that include feed efficiency as one of the key traits. Genetic variation in feed efficiency and in the birds' requirements for major-cost components of the diet are known to exist. With ever-increasing feed costs, even small genetic improvements per generation in feed efficiency are important because, as mentioned above, such improvements are cumulative both over years and numbers of birds. This subject must be investigated in the context of selection for a balanced bird with all the other necessary traits for economic egg production.

Similarly, priority should be placed on genetic techniques for improving eggshell quality, improving general resistance to disease and improving persistency in rate of production, all within selection programs designed to produce a bird with the overall balance of traits needed for efficient production of marketable eggs.

A by-product of this work is that it will be necessary to maintain control populations against which the geneticists will measure genetic changes in selected populations and which will serve as valuable reserves or as broad-based pools of genes.

These 'reserves of genetic material' will be available to the breeding industry (and to the other research programs) in case they are needed for the future development of a new strain or strains for special ecological niches. These studies will result in the development and maintenance of populations with known disease-resistance traits, physiological parameters, and nutritional requirements, and whose general genetic characteristics are well known. As a result, these stocks will be extremely valuable as base stocks for studies of high-priority problems in the research areas of nutrition, physiology and management, environment and disease, as well as in studies on genotype-environment interactions discussed above. The continued support of such research will also provide the basic material and data required for the conduct of essential academic programs for well-trained professionals.

Although the cost of conducting such research is high, the 'net cost' is not as high if the return for the eggs produced is considered. It should be possible to use these returns to at least partially finance the research.

Ever since research workers at the Poultry Research Center in Edinburgh observed that some hens stand up to lay an egg while others sit, and that the latter had fewer cracked eggs, it has been apparent that there is a need for studies on the inheritance of such behavioral traits to see if it is possible to select for hens with the type of behavior that favors the production of numerous high-quality eggs. Traits such as flightiness and the ability to withstand the stress of the cage environment require detailed genetic and breeding studies to determine if selection for the desired behavioral traits can be incorporated into a multi-trait selection program. Studies of this type will be relatively long-term (5 years or more) and relatively costly, but if done in conjunction with other selection work utilizing base populations and gene pools, the studies need not be unduly costly.

Within the genetic research needs discussed, there should be effort and funding reserved for projects of a fundamental nature that are needed to investigate practical and high-priority problems. The amount of this research should be relatively small, but the results from it may be essential for achieving progress in high-priority problems of a practical and applied nature. Although the results of basic research are less certain and the time involved is less definite, this research must not be neglected.

In conclusion, it is necessary to recognize that research on egg-laying stocks is absolutely necessary and must be supported if the industry is to continue to prosper in the long-term. The complexity of the problem has been recognized. The extent and type of support required and the need to obtain as much and as wide an input of advice as possible is an indication of the seriousness of the task. The need for research support has been recognized, and also the complexity of determining where this support should be placed. The best use of the resources will have a very important and long-term effect on the health and success of the Canadian egg-production industry.

Bibliography

Bohren, B. B. 1970. Genetic gains in annual egg production from selection on early part-records. World's Poultry Sci. J. 26:247-657.

Clayton, G. L. 1978. Genetics in the poultry industry? World's Poultry Sci. J. 34:205-208.

Dickerson, G. E. and F. S. Mather. 1976. Evidence concerning genetic improvement in commercial stocks of layers. Poultry Sci. J. 55:2327-2342.

Flock, D. 1977. Commercial breeding of laying type chickens. Lohmann Information, Lohmann Tierzucht Gmbh, Cuxhaven, F.G.R.

Fox, S. 1978. The status and significance of random sample testing in Europe. World's Poultry Sci. J. 34:28-37.

Fredeen, H. T. 1977. Animal breeding today—Its dimensions and accomplishments. Can J. of Genet. and Cytol. 19:193-210.

Gavora, J. S. and J. L. Spencer, 1978. Breeding or genetic resistance to disease: Specific or general? World's Poult. Sci. J. 34:137-148.

Gowe, R. S. 1977. Multiple-trait selection in egg stocks. 1. Performance of six selected lines derived from three base population. 2. Changes in genetic parameters over time in the six selected strains. 26th Annual National Poultry Breeders' Roundtable, Kansas City, Missouri, pp. 68-91.

Gowe, R. S., A. S. Johnson, J. H. Downs, R. Gibson, W. F. Mountain, J. H. Strain and B. F. Tinney. 1959. Environment and poultry breeding problems. 4. The value of a random-bred control strain in a selection study. Poultry Sci. 38:443-462.

Gowe, R. S., W. E. Lentz and J. H. Strain. 1973. Long-term selection for egg production in several strains of White Leghorns: Performance of selected and control strains including genetic parameters of two control strains. 4th Europe. Poult. Conf., London, pp. 225-245.

Gowe, R. S., A. Robertson and B. D. H. Latter. 1958. Environment and poultry breeding problems. 5. The design of poultry control strains. Poult. Sci. 38:462-471.

Grunder, A. A. 1979. Biochemical approaches to genetic variation. 28th Annual National Poultry Breeders' Roundtable, Memphis, Tenn. (in press).

Hamilton, R. M. G., K. G. Hollands, P. W. Voisey and A. A. Grunder. 1979. Relationship between eggshell quality and shell breakage and factors that affect shell breakage in the field—A review. World's Poult. Sci. J. (in press).

Hill, W. G. 1971. Theoretical aspects of crossbreeding. Ann. Genet. Sel. anim. 3(1):23-34.

Hill, W. G. 1972. Estimation of genetic change. 1. General theory and design of control populations. Anim. Br. Abstr. 40:1-15.

Hill, W. G. 1972. Estimation of genetic change. II. Experimental evaluation of control populations. Anim. Br. Abstr. 40:193-213.

Kendall, D. 1979. Miracle on the Amazon. The Canadian (Aug. 4), pp. 1-5.

Lewontin, R. C. 1978. Molecular approaches to the study of genetic variation. 27th Annual National Poultry Breeders' Roundtable, Kansas City, Missouri, pp. 130-139.

McBridge, G. 1958. The environment and animal breeding problems. Anim. Br. Abstr. 26:349-358.

Nesheim, M. C. 1975. Genetic variation in nutritional requirements of poultry in *Effect of genetic variance on nutritional requirements of animals.* Sunde, M. L. (ed.), Nat. Acad. Sci., Washington, D.C.

Rodda, D. D., G. W. Friars, J. S. Gavora and E. S. Meritt. 1977. Genetic parameter estimates and strain comparisons of egg compositional traits. Br. Poult. Sci. 18:459-473.

Washburn, K. W. 1978. Genetic variation in the chemical composition of the egg. Poult. Sci. 58:529-535.

Nutrition: Energy and Protein

A report by R. Blair, A. Shires and H. L. Classen, Department of Animal and Poultry Science, University of Saskatchewan, Saskatoon, Sask.

Energy

The mature modern laying hen consumes feed largely to satisfy its energy needs, which vary directly with the rate of egg output, body size and behavioral activity, and inversely with environmental temperature over a range of about 0-40°C. The maintenance energy needs are high in relation to total energy needs (about 65%), therefore a reduction in maintenance energy requirements would significantly improve the efficiency of energy utilization. Means by which these requirements can be reduced include the use of smaller laying stock, caging, varying the numbers of birds per cage, raising the environmental temperature, ensuring an adequate feather cover and regulating feed intake.

A feature of the mature laying hen of the White Leghorn type is its ability, within limits, to adjust feed intake according to the concentration of energy in the diet. Thus with diets containing up to about 3000 kcal/kg of metabolizable energy (ME), the hen adjusts its intake to consume around 300 kcal ME per day. With a higher energy concentration in the feed, however, the adjustment is less exact and intake normally increases above 300 kcal ME per day, the excess being mainly deposited as body fat since egg production is rarely improved. This has the undesirable effect of increasing the energy requirement for maintenance and it can predispose the bird to diseases such as fatty liver syndrome. One beneficial effect is probably an increase in egg size. However, on balance the process can be considered as being wasteful. Further work should be carried out to define the responses of layers throughout the laying period to variation in energy concentration of the diet in an attempt to optimize energy intake and to minimize maintenance energy needs, especially after peak production and the attainment of mature body size.

Metabolizable Energy (ME) Evaluation

It is generally accepted that ME values provide a reliable estimate of the available energy content of feedstuffs for poultry. Apparent metabolizable energy (AME) is the difference between the gross energy of the feed eaten and the gross energy of the feces and urine.

AME = gross energy (GE) of feed—gross energy (GE) of excreta.

The term 'apparent' is used because the excreta of an animal contain energy which is not derived directly from the feed, namely the metabolic fecal energy (FE_m) and the endogenous urinary energy (UE_e). The measurement of true metabolizable energy (TME) involves the correction of the gross energy of the excreta for $FE_m + UE_e$ losses and may provide a more reliable estimate of the available energy content of a feedstuff (Sibbald, 1975 a).

TME = GE of feed − [GE of excreta − (FE_m + UE_e)]

It is known that part of the ME is stored in the body as protein and that the breakdown of body protein yields excretory products which contains appreciable quantities of energy. Correction to an equal level of nitrogen retention eliminates the variation in nitrogen retention associated with the age of the assay bird and with the level of dietary protein. It is common practice to correct AME values to zero nitrogen retention (AME_n), but European workers have suggested that it would be more appropriate to correct to a nitrogen retention of 25 or 33.3% as this approximates nitrogen retention on practical diets. It is evident that the use and degree of nitrogen correction is controversial and needs to be standardized.

The proposal to require feed manufacturers in Canada to guarantee the ME content of poultry diets is dependent upon the development of assays which are simple and rapid to conduct, and yield accurate and reproducible data. The conventional methods of measuring ME are laborious, expensive, and impracticable for the routine assay of individual samples of feedstuffs and diets (Sibbald, 1975 b). Two bioassays have been described recently which are relatively simple and fast, and yield reproducible estimates of AME (Farrell, 1978) or TME (Sibbald, 1976).

A collaborative study has shown that considerable variation existed between laboratories in the conventional methods of measuring AME with chickens and in the values obtained from these bioassays (Sibbald, 1978). The AME_n values of subsamples of corn ranged from 3.08 to 4.03 kcal/g of dry matter with a mean of 3.53 ± 0.07 kcal. In contrast, the assays for TME yielded less-variable data. The TME values of corn ranged from 3.98 to 4.15 kcal/g of dry matter with a mean of 4.10 ± 0.02 kcal. Thus, there is need:

- To compare the new rapid bioassays for AME and TME with conventional methods of measuring ME in relation to ease, accuracy and repeatability of determinations, biological performance and profitability.
- To establish a standard method of ME determination.
- To adopt a single type of ME value for the expression of energy values of feedstuffs and energy requirements of poultry.

Progress in improving the nutritional value of cereal grains and seeds by breeding is dependent on the development of rapid biological and chemical

tests for measuring the availability of energy and amino acids in the new crops. Recent studies indicate that the bioassay developed by Sibbald (1976) for the determination of TME may also be used for measuring the availability of amino acids in feedstuffs.

Body Size and Strain

As body size increases, energy requirements for basal metabolism and activity also increase. Using the predictive equations described by Scott, Nesheim and Young (1976), an increase in body size from 1.75 to 2.75 kg would result in an increased energy requirement of 86 kcal per bird daily. Only minor variation in body weight exists among commercial White Leghorn strains, but major body weight differences exist between the Leghorn and brown-egg strains.

Variation in the energy requirements of different strains has been shown on numerous occasions. In a recent experiment, Hurnik (1977) examined the efficiency of laying hens and found that 40% of the variation noted could not be explained by body weight and production characteristics. Morrison and Leeson (1979) demonstrated that differences in metabolic rate and activity may account for the unexplained efficiency of feed utilization. Additional research is required to establish the reason for efficiency differences.

Environmental Temperature

For every 1°C increase in environmental temperature, feed consumption of laying hens drops approximately 2%. This reduction in feed consumption is primarily due to the reduction in the energy temperature maintenance. Table 6 demonstrates the influence of temperature on the ME requirements of laying hens as estimated by Reid (1979).

Obvious savings in feed costs may be derived from increased environmental temperature in the barn. Because of the reduced feed consumption of birds housed under higher environmental temperatures, formulation of diets must compensate by increasing the levels of protein, vitamins and minerals.

TABLE 6. Estimated ME Requirements of Laying Hens

Body weight kg	Egg output g/day	Temperature 18°C	24°C	30°C
1.75	0	180	172	163
	40	278	270	261
	50	303	295	286
	0	199	190	180
2.00	40	297	288	278
	50	322	313	303

Source of energy is also important. Reid (1979) demonstrated that the addition of fat improved the productivity of hens exposed to high environmental temperatures because of a lowered heat increment of diets containing fats. Additional research on the influence of high environmental temperatures and appropriate diets is required to make such a management system feasible in practice. A factor that needs to be taken into account in such studies is the effect on egg size. Results to date suggest that egg size is depressed by about 1 g/egg for each 3°C increase in environmental temperature. Research and knowledge of housing considerations, such as insulation and ventilation requirements, are needed to gain maximum efficiency of feed utilization.

Housing and Management Systems

Activity has an important impact on the energy requirements and is influenced by housing and management systems. For example, housing birds in cages rather than in floor pens reduces the energy requirement by approximately 9% (Scott *et al.*, 1976). Recent housing and management systems requiring further research include the use of shallow cages and intermittent lighting regimes. In addition, housing and management systems may influence the degree of feathering. The result of poor feathering is decreased insulation and increased maintenance energy requirements.

Regulation of Energy Intake

The observation that heavy strains tend to overeat and become fat led to the practice of restricted feeding for broiler parent stock. Recent studies with commercial laying strains indicate that regulation of feed intake can improve the efficiency of energy utilization and may provide a means of reducing the cost of egg production.

It has been reported that restricting the feed intake of laying hens by 5 to 10% of the *ad libitum* intake results in an improvement in the efficiency of feed utilization and a decrease in the rate of body weight gain without affecting mortality. Egg weight and the rate of egg production are usually reduced by restricted feeding, although in some cases little difference in egg production has been reported. Reid *et al.* (1978) found that for each 10 kcal reduction in ME intake from 296 to 51 kcal per hen a day there was a reduction of 1.53 g in egg weight and a reduction of 2.5% in egg production. The use of an intermittent lighting program after the peak of production has been reported to reduce the consumption of feed and electricity without affecting egg weight or the rate of egg production. Further work is required to develop practical methods of

controlling the energy intake of laying hens and to establish the economic value of regulated feeding programs, especially in flocks that have passed peak production.

Whole Grain

Birds are designed to utilize whole grains, yet modern feeding systems are generally based on grains incorporated into feeds in a ground form. Several workers have shown that whole grain can be used successfully in layer feeding systems, but this area requires more attention. Use of whole grain would avoid the necessity for grinding, which is a fairly slow and energy-expensive operation. The project could be extended to moist grain with a view to avoiding the need for post-harvest dehydration, which again requires energy and also can reduce the nutritional value of the grain.

Protein

It is generally agreed that for optimal output, the mature laying hen of the White Leghorn type requires an intake of around 17 g of good-quality protein daily. Since an egg contains around 7 g protein, it follows that the gross efficiency of protein utilization in the hen laying at a rate of 1 egg per day is only about 41%. Taking the maintenance requirement into account raises this value to 55%. Therefore, a long-term research aim should be to increase the efficiency of protein utilization.

Utilization of the 17 g protein required daily is as follows (Scott, *et al.*, 1976):

	g/day
Production of an egg	13.5
Maintenance	3.4
Feather growth	0.1
	17.0

The young hen requires an additional 1.4 g of protein per day for growth, but this is compensated for by a reduced protein requirement for egg production.

Overall efficiency could be improved by reduction in the amount of protein required for egg production, and/or for maintenance.

As the laying cycle progresses, it is logical to consider a reduction in protein intake to correspond with the normal reduction in egg output and the increased feed consumption of the older hen. The intent is to avoid protein wastage. However, more work should be done in this area since some workers claim that older hens have a reduced ability to utilize dietary protein. Other work, for instance, carried out in Britain at the Gleadthorpe Experimental Husbandry Farm (Hearn, personal communication), suggests that after birds are about 1 year of age, the dietary protein level can be reduced satisfactorily, provided the 17 g intake of protein is maintained. This result confirms the recommendation for maintaining the protein intake at 17 g per day throughout the laying year.

Some workers have shown that output can be increased by raising the protein to 20 g per day. However, Hearn (personal communication) showed that this was not economic under 27 different market situations.

The effect of a slightly inadequate protein intake, say from 17 to 15.5 g daily, is to reduce egg size from around 60 g to 58.5 g. This is probably the first effect noted. Rate of lay may be reduced, for example, from 80 to 77% and feed intake may be reduced by 2%. In addition, feather loss is probably increased as is the susceptibility to disease.

As with several other nutrients, the protein requirement is best considered in terms of daily intake rather than as a level in the diet. This is because feed intake can be variable (as discussed previously). The logical approach would be to set the protein level in the diet according to the level of feed intake, as exemplified in Table 7.

It has been pointed out by Summers (1978) that the use of phase-feeding programs based only on age of the flock is often unsuccessful because feed intake is not taken into account.

More work should be carried out on flock feeding, using diet formulation systems based on the pattern of feed intake. There is a great deal of logic in the system, especially for large integrated flocks, and it could result in worthwhile savings. To assist in its application on farms, a simplified procedure for the measurement of feed intake should be developed.

The system proposed could involve a flock in frequent changes in feed composition, and several workers have investigated this area. Hearn (personal communication) used four diets, (two high-energy and two medium-energy) and found no difference in average performance when they were fed either continuously, or in 24 different sequences with a change made every 7 weeks. The adjustment of feed intake to a change in energy level took about 3 weeks for completion. Summers (1978) found that marked variations in diet resulted in similar hen

Table 7. Protein Level in Diet of High-producing Layer Flock

Feed intake g/bird/day	Recommended dietary protein level (%)	Protein intake g/bird/day
90	19	17
100	17	17
110	15.5	17

performance, provided nutrient specifications were maintained. A constant corn-soy diet was compared with diets formulated every 28 days, with either no constraints on the level of ingredients or with constraints typical of those used in practice. Only small differences were noted although the test diets changed markedly. The test diets were less expensive than the corn-soy diet. The best overall result was obtained with a conventional 'least-cost' diet. These results also confirm the validity of using linear-programmed diets in modern egg production.

Factors Affecting Protein Requirement

These factors may be stated briefly as follows:

- Size and strain. The White Leghorn hen lays about 270 eggs a year and has a daily protein requirement of around 17 g. Heavier strains (e.g., some brown-egg layers) lay fewer eggs and if fed a normal layer diet, consume 20-25 g of protein daily. Therefore, the smaller bird is more efficient, and hence its use in modern production.
- Protein quality. A protein is described as being of high quality if the essential amino acids contained in it are in a highly digestible form and are in the proportions that meet closely the requirements of the bird. Normally, the amino acids in the diet are derived from several sources (grains, protein supplements and possibly a synthetic source in the case of methionine) to ensure an adequate mixture. Recommended amino acid intakes are shown in Table 8.

TABLE 8. Recommended Intakes of Amino Acids

Amino acids	g/bird/day
Arginine	0.7—0.85
Histidine	0.34
Isoleucine	0.6—0.85
Leucine	1.28
Lysine	0.72—0.75
Methionine	0.34—0.36
Phenylalanine	0.78
Threonine	0.52—0.63
Tryptophan	0.17
Valine	0.73

The effects of an amino acid deficiency are somewhat similar to those described for a protein deficiency. However, the degree of deficiency is important. With a slight deficiency, the bird appears to compensate to some extent by eating more feed. With a severe deficiency, compensation is not possible and feed intake and egg output are reduced.

Several workers have shown that satisfactory performance can be obtained with a reduced dietary protein intake, provided the proper balance and levels of essential amino acids are maintained (Mitoku *et al.*, 1970; Blair and Young, 1974; Blair *et al.*, 1976; Picard, 1979). A long-term aim of layer research should be to determine the minimal levels of amino acids necessary for satisfactory production. Supplementation work with synthetic amino acids should be continued. This area of research would have two main aims: a reduction in the protein needs of layers and a more efficient utilization of protein supplies.

Part of this research program should be a continuing effort to establish suitable methods for estimating amino acid availability in feeds, with a view to deriving available amino acid requirements. The methods suitable for application in the feed industry would have to be rapid, inexpensive and yield results that gave a good prediction of performance under practical conditions.

A continuing effort should be made to maximize the use of indigenous protein feedstuffs such as rapeseed meal, and reduce dependence on imported protein feeds. Rapeseed meal still needs to be improved before it can compete nutritionally with soybean meal, but even now it is underused in layer feeds. Alternate protein sources such as fababeans, field peas, and processed industrial and farm by-products and wastes should be studied as potential feed sources. Valuable work has already been carried out in this area. Auckland (1978) showed that the grain content of a layer diet could be halved and dehydrated poultry waste, a fat source, offal meal and dehydrated potato meal substituted, with a drop in egg production of only 3%. The need for the involvement of an animal nutritionist in programs to develop new crops is highlighted by the work of the Lethbridge Research Station in developing high-protein wheats. Gardiner and Dubetz (1977) showed that Neepawa wheat containing 21% protein was poorly balanced in amino acids and required supplementation with the synthetic amino acid lysine before being suitable for inclusion in layer feeds. However, the crop is promising in that it could be used to replace soybean meal.

The development of high-protein wheats and other grains for feed use should be encouraged by a system of pricing based on protein content.

Normally it is assumed that maximum profit is obtained with layers when output is maximized. This is not necessarily true in all circumstances. Thus, it might be profitable under some market situations to deliberately allow egg size to drop, e.g., by lowering protein intake. However, the relationship between protein intake and egg output has not been refined to the point that it is capable of widespread application. More research should be carried out on quantifying the relationship in exact terms, using the absolute daily intakes of protein, amino acids (and other

nutrients) as a basis for an input-output model. Establishing the model on this basis would remove many of the complications due to strain, body weight, temperature, season of year, stage of production, etc. Because of the large number of calculations involved, the research would have to involve a computer.

The model should allow the following to be maximized, depending on the aims of the user: output, efficiency of nutrient utilization, and profit.

It is probable that much of the biological data required for the model has been researched, and that further biological experimentation could be confined to the derivation of data required to validate the model over a wide range of practical situations.

Biological Testing of Layer Rations

From time to time it is suggested that feed tests similar to the random sample egg-laying tests should be set up to allow comparisons to be made on commercially available feeds. Biely, Bragg and Stapleton (1976) reported a significant feed source effect, with average eggs/bird housed over a 4-5 year period varying from 242-256. They suggested that some commercial feeds gave better results than others, but this performance could only be assessed over several years. Since this type of test, if approved, should probably be organized on a provincial rather thn national basis, it will not be considered further in this review.

Suggested Research Topics (in priority order)

Short-term

1. Comparison of the new rapid bioassays for AME and TME with conventional methods of measuring ME in relation to ease, accuracy and repeatability of determinations, biological performance, and cost.
2. Establishment of a standard method of ME determination.
3. Adoption of a single type of ME value for the expression of energy values of feedstuffs and energy requirements of poultry, in collaboration with a body such as the Expert Committee on Animal Nutrition.
4. Economic evaluation of raising the temperature of the laying house to reduce the feed energy costs of maintenance.
5. Feeding regimes that result in minimum weight gains after maturity should be devised, to reduce maintenance costs and improve bird health. This will involve development of practical ways of controlling the energy intake of laying hens and economic evaluation of restricted feeding programs.
6. Establishment of a standard method of measuring the availability of amino acids in feedstuffs.
7. Work is required to define more exactly the relationships between energy, protein and amino acid intakes and egg output, with the aim of establishing a comprehensive economic input-output model.
8. Improvement in the nutritional value of cereal grains and seeds by breeding is dependent on the development of rapid biological and chemical tests for measuring the availability of energy and amino acids in the new crops. Rapid and cheap chemical tests are also required for the routine assay of the nutritive value of feedstuffs and mixed diets.
9. A study of the relative value of corn in layer diets is required. This is a controversial topic in Western Canada and feed manufacturers would like to have more data.
10. The relative merits of feed texture (i.e., pellets, crumbs and mash) should be established on an economic basis.
11. Investigations should be carried out on feed-processing techniques, such as enzyme and heat treatment to improve nutrient availability.
12. Work should be initiated on a study of whole grain, and extended to include moist grain.

Long-term

1. Establishment of the available amino acid requirements of laying hens.
2. Basic knowledge of digestion and absorption needs to be extended, with the aim of improving efficiency of feed utilization. For instance, it appears that efficiency of utilization is higher in the pig than in the bird, suggesting a potential for improvement.
3. Work needs to be continued on the utilization of indigenous protein feedstuffs such as rapeseed meal, to reduce dependence on imported protein feeds. The nutritional value of protein feedstuffs, particularly newer types such as field peas, fababeans and sunflower seed should be established, on an ongoing basis.
4. The potential for the amino acid supplementation of diets should be established.
5. Establishment of the nutritional value of grains, particularly new varieties, on an ongoing basis.
6. Work needs to be continued on alternative protein sources such as high-protein grains, dehydrated alfalfa, industrial and agricultural wastes and by-products.
7. The nutrient requirements of layers should be reassessed periodically as new genetic strains are introduced.

References
Auckland, J. N. 1978. Br. Poult. Sci., 19: 327-331
Biely, J., D. B. Bragg and P. Stapleton, 1976. Wld's Poult. Sci. J., 32: 176-184
Blair, R., D. J. W. Lee, C. Fisher and C. C. McCorquodale. 1976. Br. Poult. Sci., 17: 427-440
Blair, R. and R. J. Young. 1974. Poult. Sci., 53: 391-400
Farrell, D. J. 1978. Br. Poult. Sci., 19: 303-308
Gardiner, E. E. and S. Dubetz. 1977. Br. Poult. Sci., 18: 275-281
Hurnik, J. F. 1977. Proc. Poult. Ind. School, Guelph, Ont.
Mitoku, S., Y. Ohori, S. Ebisawa and K. Kinbara. 1970. Jap. Poult. Sci., 7: 131-138
Morrison, W. D. and S. Leeson. 1979. Proc. Poult. Ind. School, Guelph, Ont.
Picard, M. 1979. Proc. Guelph Nutr. Conf., 16-20
Reid, B. L. 1979. Proc. Georgia Nutr. Conf. 15-24
Reid, B. L., M. E. Valencia and P. M. Maiorino. 1978. Poult. Sci., 57: 461-465
Scott, M. L., M. C. Nesheim and R. J. Young. 1976. Nutrition of the chicken. M. L. Scott and Associates, Ithaca, New York.
Sibbald, I. R. 1975-a. Poult. Sci., 54: 1990-1997
Sibbald, I. R. 1975-b. Feedstuffs, Minneap. 47(7): 22-24
Sibbald, I. R. 1976. Poult. Sci., 55: 303-308
Sibbald, I. R. 1978. Feedstuffs, Minneap. 50(48): 20-22
Summers, J. D. 1978. Proc. Ark. Nutr. Conf., 1-8
Young, R. J., M. L. Scott, R. E. Austic and G. F. Combs, Jr. 1976. Proc. Cornell Nutr. Conf. 45-58

Nutrition: Minerals, Vitamins and Antibiotics

A report by Steven Leeson and John D. Summers, Department of Animal and Poultry Science, University of Guelph, Guelph, Ont.

This section presents an overview of the scientific knowledge and most-promising areas of research into the nutritional aspects of minerals, vitamins and antibiotics for growing pullets and laying hens. Since the topic is very broad, the authors have concentrated on what they consider to be the main areas of interest and have not attempted to discuss all the minerals and vitamins or all the aspects of antibiotics relative to nutrition and production.

Minerals

Although there is continuing effort to study the metabolism of selected minerals, in recent years studies on mineral requirements have received little attention from research workers. Thus present-day requirement values are derived from data obtained some 20-30 years ago from work that was undertaken with strains of birds that are no longer in use and with management and feeding programs that are no longer applicable.

Fortunately, most minerals are not costly and deficiencies seldom occur because feed manufacturers provide substantial safety margins. However, at a recent meeting of the Expert Committee on Animal Nutrition (which reports to the Canadian Agricultural Services Coordinating Committee), it was intimated that mineral and vitamin specifications for poultry diets may come under close government scrutiny, and that maximum inclusion levels may be regulated. This is to ensure that producers do not pay ever-increasing costs for unwarranted levels of such minerals, and also that residues of these minerals do not reach undue levels in poultry products.

There is no research data yet to substantiate or refute such actions and hence should such government regulation occur, reassessment of mineral requirements and toxicities will be a priority. If specifications are restricted to two times the National Research Council recommendations (tentative proposal), what effect will this have on bird performance and producer returns? Will modern strains of birds be able to produce effectively with such levels of minerals under all situations likely to arise in the laying house? On the other hand, if five or ten times the absolute requirements are continued to be fed, what is the ultimate fate of these nutrients? Do they pose a threat to human health, and at these levels are other nutrients being adversely (and unknowingly) affected?

Research proposal	—Reassessment of mineral requirements of all ages of pullet and laying hens.
Category	—High priority, 5-year study.

Calcium

Because of its involvement in shell structure, calcium metabolism continues to receive considerable attention. A recent American directory of research shows that all universities with active poultry groups were studying the role of calcium in eggshell quality. The same is true in Canada.

Recent work has indicated that shell mass alters little with age of hen and, consequently, deterioration of shell quality may be associated with the fact that the bird has to encase an ever-increasing egg size with a constant shell mass.

Simply increasing the calcium content of the diet does not result in more calcium being absorbed—the greater the calcium content of the diet, the lower the proportional absorption. However, when given a choice of diets containing widely

different levels of calcium, hens are able to differentiate and balance intake accordingly. This effect has been utilized in a free-choice feeding program that results in reduced overall feed intake, comparable egg production and improved shell quality. The effect on shell quality is thought to be due to the timing of calcium intake. In addition to the absolute daily intake, the timing of the intake in relation to shell calcification may be important in optimizing the process of shell deposition.

Research continues into the effect of different sources of calcium, with limestone and oystershell being the sources most commonly compared. The particle size of these ingredients has also received considerable attention. Oystershell often appears to be the best source of calcium in terms of shell quality, although on a practical basis, the higher cost of this ingredient must be considered.

Detailed studies have recently indicated that birds producing poor eggshells excrete less sodium and potassium but more calcium in their feces that do 'normal' birds. This type of study indicates the interrelationship of calcium with other elements, and it is likely that such studies will ultimately be more fruitful than more-conventional studies comparing various levels of dietary calcium.

The exact effects of calcium metabolism, during the late growing stage, upon subsequent calcium metabolism during egg production is not clear. Some workers suggest that the low level of dietary calcium immediately prior to lay will make the bird's absorptive process highly efficient, so that when the bird is offered a high-calcium laying diet it is able to extract the maximum quantity of calcium for shell calcification. However, more recent work suggests that 1% dietary calcium prior to lay is inadequate for maximum bone mobilization, and that 3.5% calcium during the 18-to 22-week period significantly increases bone ash content. This may be important with respect to cage layer fatigue and other associated leg problems.

Since considerable effort has already been expended on this topic, it is unlikely that future work will give immediate answers.

Research proposal —Study of calcium metabolism pertaining to shell quality.

Category —Medium priority, 10-year study.

Phosphorus

Research into the phosphorus requirements of the laying hen continues because of this mineral's involvement in calcium metabolism and cage layer fatigue, and because of its relatively high cost.

Recent work suggests a general reduction in diet specifications, with 0.4% available phosphorus being commonly recommended. While this level has been advocated by many research workers, extension personnel in the southern United States have suggested that these lower levels are not adequate under field conditions.

There seems little doubt that too-high levels have been used in the past and that this is not only a waste of money, but it has been shown that excessive amounts are detrimental to shell quality. One report detailed 0.19% available phosphorus as being adequate for egg production, while 0.28% was necessary for optimum livability. Because of its many functions in the hen's body, it is likely that phosphorus requirements will vary commensurate with specific situations of environment, health and production.

Work continues on the availability of phosphorus from various phosphate sources. The results are somewhat contradictory, although a general conclusion is that impurities, such as vanadium and aluminium, can cause significant problems in terms of livability and production.

Research proposal —Identification of optimum phosphorus requirement of layers.

Category —Medium priority, 5-year study.

Sodium

There has been renewed interest in sodium metabolism, since sub-optimal levels (for production) of this mineral can be used to induce a pause in the laying cycle. Depending on the economics of production, a second cycle of lay may be warranted and this can be achieved by withdrawing the salt from the diet. This action is advantageous with conventional force-molting techniques, since it is possible to terminate and initiate egg production much more quickly. Egg production will cease in 14-21 days through such action and, more importantly, resumption of salt in the laying diet brings about a rapid return to peak production—80% within 16 days.

Problems of sodium toxicity have occured in certain situations where water softeners are used, since in the water-softening process the hard minerals in the water are removed and sodium is often the mineral that is added. Depending on the salt content of the diet, such action can predispose a mild sodium toxicity, most often diagnosed from the initial condition of wet droppings. Manipulation of sodium concentrations in the diet, for whatever reason, therefore requires prior knowledge of the sodium status of the drinking water.

Recent work has suggested some control of growth in pullets when fed diets containing sub-optimal levels of salt (relative to National Research Council recommendations). This may be a potential method of regulating pullet growth and sexual maturity.

Research proposal— 1. Induction of pause in lay through manipulation of dietary sodium.

—2. Control of pullet maturity through manipulation of dietary sodium.

Category —Low priority, 5-year study.

Selenium

Depending on geographical location (related to the selenium content of soils, and hence local feedstuffs), substantial improvements in performance have been recorded when this mineral is added to the diet of the laying hen. However, government regulation presently forbids the inclusion of selenium in such diets and, consequently, practical applications are not valid at this time.

Research proposal —Selenium requirement of laying hens and carryover into egg and muscle.

Category —High priority, 5-year study.

Heavy Metals

Research continues into the toxic effects of heavy metals on the performance of laying hens. Since such dietary situations are unlikely to occur naturally, practical applications are limited. However, it is necessary to note the effect of these elements on bird performance, and their subsequent accumulation in end products.

Research proposal —Study of heavy-metal metabolism in laying hens.

Category —Low priority, 5-year study.

Vitamins

Little work has been done in recent years on quantifying the absolute vitamin requirements for modern strains of laying hens. However, because of the increasing number of field reports of problems apparently related to vitamin metabolism, this topic deserves more detailed study.

A recent report detailed differences between strains for egg production and for hatchability. This is somewhat surprising since such differences are not allowed for in published recommendations. It has already been mentioned that government intervention is being contemplated with respect to setting maximum specifications for vitamin levels in poultry diets. Should this occur, and should these strain differences subsequently be proven to be widespread and of a substantial magnitude, then such action may conceivably result in production problems.

In general, vitamins are the most unstable nutrients in a diet; consequently, safety margins in dietary specifications are needed. One of the prominent factors potentially responsible for vitamin degradation is contact with minerals, e.g., iron and copper salts. This effect is not controlled in situations of on-farm diet preparation, where mineral-vitamin premixes are invariably used. In theory this does not appear to be the ideal situation for stability of certain vitamins. Separation (until final mixing) of these ingredients seems most logical. However, there is no practical research data available on which to base recommendations of vitamin storage and stability under practical situations. The whole area of vitamin stability thus deserves immediate attention.

Research proposal 1.—Study of vitamin requirements of layers with emphasis on strain effects.

Category —Medium priority, 5-year study.

Research proposal 2.—Study of vitamin stability with on-farm storage.

Category —High priority, 2-year study.

Vitamin D_3

Many recent reports have dealt with the potency of various forms of vitamin D. Vitamin D_3 (cholecalciferol) is essential for normal absorption of calcium in the intestine. Passing through the various body systems, cholecalciferol is chemically transformed, and it is these transformed products (metabolites) that are now being tested as diet ingredients. There are some conflicting reports, although recent evidence indicates improvement in the absorption of calcium when these different forms of vatamin D_3 are used in the diet. In this situation, however, shell quality was not improved, suggesting that calcium absorption by the intestine is not a limiting factor for shell quality.

Other recent work indicates improvement in shell quality with the D_3 metabolites, especially when used with older hens and those in the second year of production. Still other work indicates that the D_3 metabolites improve the utilization of phosphorus, and that egg production and shell quality are improved when these metabolites are in combination with sub-marginal levels of phosphorus.

A problem with eggshell quality has recently been described as being associated with mycotoxin inhibition of vitamin D absorption. The mycotoxin, thought to be a *Fusarium* species commonly found in corn, apparently blocks the absorption of fat soluble forms of vitamin D in the intestine. The situation does not respond to additional fat soluble (common form) vitamin D in the diet, but is responsive to water soluble forms of vitamin D. Because of

the prevalence of molds and associated mycotoxins found in feedstuffs, this topic deserves further study.

Research proposal —Continuation of present studies on the role of various vitamin D_3 metabolites in calcium and phosphorus balance in relation to shell quality.

Category —Medium priority, 5-year study.

Vitamin E

The metabolism of vitamin E has most recently been studied in relation to its involvement with the mineral selenium. To a certain extent, selenium duplicates the function of vitamin E (biological antioxidant) and this complicates their study since neither can, nor should, be studied in isolation. However, there are no reported instances of field problems related to vitamin E metabolism. Improvements in fertility, egg production and hatchability have been observed when vitamin E and selenium have been added to specially formulated experimental diets, and therefore further work in this area may be warranted. A greater volume of work is presently being conducted with the chick and meat-type bird, where substantial responses are often recorded.

Research proposal —Study of vitamin E-selenium responsive condition in layers.

Category —Medium priority, 5-year study.

B-group Vitamins

Classical deficiencies of B-group vitamins are seldom seen in the field, although a number of apparent deficiencies have recently been reported. Thus, although diets are analytically sufficient in terms of folacin and niacin, deficiencies have been reported where diets containing high levels of meat meal and fish meal have been used. This situation is most likely to occur in east or west coast areas.

We have seen an apparent deficiency of riboflavin in breeder flocks, although the diet was supplemented with the vitamin. However, hens did respond to added riboflavin. An apparent riboflavin deficiency was recently observed in chicks, severe leg problems being the main manifestation. Birds responded dramatically to riboflavin injections.

It appears that vitamin problems in the field are occurring with increasing regularity, and it will be necessary to isolate the compounding factors associated with these problems.

Although biotin has been shown to be intimately involved in the fatty liver and kidney syndrome of chicks, additional biotin has not been beneficial in reducing the fatty liver syndrome in layers, and hence this is an unrelated situation. High dietary levels of both niacin and biotin, up to 25 times the normal level, have not altered liver fat content or influenced performance.

Research proposal —Study of the B-vitamin requirement of chicks, pullets, layers and breeders with emphasis on elucidation of dietary antagonists.

Category —Low priority, 5-year study.

Antibiotics

Antibiotics have been used in poultry feeds for about 25 years, and their beneficial effects in terms of health and production characteristics are well documented. New antibiotics are continually being developed by the competitive drug companies, with results being regularly reported in scientific literature. It was recently estimated that antibiotics in the American agricultural system resulted directly in $2 billion extra revenue.

Recent concern over the use of sub-therapeutic doses of antibiotics revolve around (1) the development of resistant organisms and their transfer to humans, and (2) tissue residues of antibiotics. Since there are no stipulated withdrawal times for the most commonly used antibiotics in poultry diets, it is assumed that this latter factor is of little concern.

Development of resistant organisms, especially Salmonella, is the main concern with respect to the safety of using antibiotics in poultry diets. Data from the United States indicates that, although the antibacterial resistance of food-poisoning Salmonella isolated from man has almost doubled in the last 5 years, the incidence of food poisoning (salmonellosis) has remained constant and, in fact, mortality from this affliction has decreased.

Sub-therapeutic levels of antibiotics are used essentially to promote weight gain and/or efficiency of utilization of feed. With the growing awareness of consumer groups and with increasing pressure from governmental regulatory agencies, it is likely that drug use *per se* will come under increasing scrutiny. As such it may be pertinent to look more deeply into the actual mode of action of antibiotics, with a view to developing management systems that will operate effectively without recourse to total dependency on antibiotics.

Research proposal 1—Development of new antibiotics with emphasis on organism resistance, e.g., Salmonella.

Category —Medium priority, 5-year study.

Research proposal 2—Development of management systems emphasizing less dependence on antibiotics.

Category —High priority, 5-year study.

Metabolism and Endocrinology

A report by R. J. Etches, Department of Animal and Poultry Science, University of Guelph, Guelph, Ont.

In this section, metabolism and endocrinology have been interpreted to include general aspects of physiology. An attempt has been made to identify areas which are or may be of concern to egg producers. Some topics which would be of concern to other segments of the poultry industry have been omitted. The list is not intended to be comprehensive, but it identifies ares of research which should be beneficial in both the short- and long-term.

Characterization of Genetically Divergent Lines

Poultry is unique in its genetic diversity and this diversity could be more fully exploited. Each different line has achieved its level of production by 'choosing' a different combination of biochemical pathways. An investigation of these different combinations of pathways will reveal two major pieces of information. Firstly, common pathways will emerge and these might be identified as major rate-limiting pathways which cannot be circumvented. These pathways might be prime targets for pharmacological manipulation. Secondly, the genetic correlation between some of these biochemical or physiological traits and classical production traits may be sufficiently high to allow indirect genetic selection. This approach has proved to be an effective method of selection in turkeys and awaits further investigation in other types of poultry. This approach has recently been adopted by one of the major broiler breeders in the United States.

Research category —Medium priority, 5- to 10-year study.

Thyroid Gland

The thyroid gland is the major controller of the speed of metabolism. The rate at which physiological events proceed can be altered by changing the output of this major regulatory center and, therefore, it has remained an intriguing possibility that hens may be able to work faster and/or more efficiently if the thyroid gland could be controlled. Despite much effort, however, this area of research has been disappointing. The correct combination of synthetic hormones has not become apparent, but we should remain aware of the potential of this gland and be cognizant of new ideas which may occur regarding its control.

Research category —Low priority, 10-year study.

Endocrine Regulation of Egg Formation

The physiological mechanisms which regulate egg formation are not well known. Recent advances have demonstrated that an increase in the rate of ovulation through hormone therapy and/or manipulation of parts of the brain is possible, but to date these techniques are confined to the laboratory. A greater understanding of the mechanisms which control and regulate the formation of the egg can only aid in the development of more-productive management systems. In particular, a knowledge of the events which occur between the perception of light and the production of an egg will allow the development of more-efficient lighting regimes, giving producers greater flexibility over egg numbers, egg size, internal egg quality, and shell quality. The recent development of ahemeral (non-24-hour) light-dark cycles owes much to this area of investigation.

The nature of hormones which are produced in response to the lighting stimulus are only now being characterized and, therefore, the benefits of this research are difficult to assess. Nevertheless, a knowledge of the relationship between hormone levels and production may reveal control mechanisms which can be exploited. In addition, these biochemical parameters may prove to be more economical and reliable measures of productivity and/or genotype than egg production itself.

Research category —Medium priority, 10-year study.

Force-molting

In the United States, it has become popular and economic to recycle hens through two or three periods of production. This is accomplished by force-molting and the conventional method of forcing a molt is the withdrawal of feed and water. This treatment is among the classical stimuli which induce a stress response and, therefore, the practice may become unacceptable. Recent research has indicated that it is possible to mimic the stress response by hormone therapy and thereby induce a period of rest without feed and water withdrawal. Similarly, metabolic stresses, such as the withdrawal of salt or calcium in the diet, will also induce periods of rest and/or molt. In addition, the physiological changes which are associated with the cessation of egg production should be examined so that the natural decline in egg production at the end of the laying year might be avoided.

Research category —High priority, 2- to 5-year study.

Growth and Sexual Maturity

One of the ways in which production could be increased would be to decrease the period of time

to sexual maturity. Indeed, a reduction in the age to sexual maturity has been the trend during the past 50 years and this change has been attributed to genetic selection. Hens possess some physiological mechanism to mark the passage of time and currently many scientists believe that time is measured by a circadian receptor (see section on Circadian Rhythm) in a specialized area of the brain (hypothalamus). This receptor 'counts' the passage of each light-dark cycle. Therefore, if the light-dark cycle is lengthened or decreased, the actual age of sexual maturity might be altered. Non-24-hour days have been used in Britain to allow early maturity without a loss in egg size. Further research is warranted in this area.

Research category —High priority, 2- to 5-year study.

Calcium Metabolism

Calcium is one of the most important minerals to consider in egg production. It is the major component of the eggshell and the deposition of calcium on the egg is of major importance in shell quality. Both basic and applied research is required in this area. Basic research is needed to elucidate the mechanism which the hen uses to turn soluble calcium in her blood into cytalline calcium on the shell. With this information, it may be possible to physiologically or pharmacologically alter the rate and/or quality of eggshell formation. In more applied areas, the effects of the light/dark cycle on shell quality need to be examined. Recent evidence has shown that exposure of the hen to 'days' which are longer than 24 hours (e.g., 14 hours of light and 13 hours of darkness) will improve shell quality considerably.

Additional research is also required in the area of a specific appetite for calcium. Recent studies have indicated that the hen has the ability to selectively withdraw calcium-rich substances from the feed. Furthermore, the hen may require different amounts of calcium at different stages of egg formation. Alternatively, the changes in calcium intake which have been reported may reflect a circadian rhythm. The resolution of these preliminary observations may lead to management practices and/or feeding regimes which will improve shell quality.

Research category —High-medium priority, 2- to 10-year study.

Stress Physiology

Stress has become one of the most important words in the language of agriculture in the 1970's and from the recent increase in symposia and publications pertaining to animal welfare, this trend will continue into the 1980's. The central theme of this discussion revolves around the response of the caged hen to her environment. The major problem in assessing this response is obtaining an objective measurement. Classical physiology has identified several organs which are involved when an animal adjusts to the environment and these are the adrenal gland, the thyroid gland, the pituitary gland, the hypothalamus and the brain. The changes in these organs can be measured using modern techniques and an assessment of the status of these organs relative to caging, feeding and management systems would bring some objectivity to the animal welfare discussions.

Research category —Medium priority, 10-year study.

Semen Freezing

Artificial insemination does not form an integral part of the egg producer's operation, but it is an important facet of the total production system. At the grandparent level, artificial insemination is widely practiced and the availability of frozen semen would facilitate the use of this technique. Artificial insemination with frozen semen could result in more-rapid increases in the genetic quality of production pullets and could decrease the cost of the pullet to the producer. Recent advances have been made in this area and it is very likely that frozen semen could be made available commercially within 5 years.

Research category—Low priority, 5-year study.

Circadian Rhythm

Circadian rhythms are changes in the biochemical reactions within the body which repeat a cycle about once a day. These rhythms have only recently been recognized, but are now regarded as one of the major regulatory mechanisms in physiology. In man, circadian rhythms are responsible for 'jet lag' when traveling to Europe or Japan. In chickens, circadian rhythms are responsible for restricting ovulation to an 8-hour period of the day. It is because of this particular circadian rhythm that most eggs are usually laid in the morning and very few in the afternoon. A better understanding of the way in which circadian rhythms regulate the timing of ovulation could lead to an ability to make more of the day 'useful' for egg production.

Another important circadian rhythm controls the response of the hen to light. Each hen appears to possess an internal clock which is 'set' at each 'dawn' or lights-on signal. From that point, the hen counts out 12 hours. If light is provided during the 12th, 13th and 14th hour, it is recognized by the brain which communicates this information to the hypothalamus. The information is then passed to the pituitary gland which works in concert with the ovary to produce eggs. Although the generalities of this scheme have recently been identified, a knowledge of the details of this system will allow a more

effective method of developing photoperiods for egg-producing hens.

To date, this work has yielded non-24-hour or ahemeral light-dark cycles which will be, and have proven, useful in controlling egg size, shell quality and age at sexual maturity (see sections on Growth and Sexual Maturity, and Calcium Metabolism).

Research category —High priority, 10-year study.

Fat Metabolism

A major concern in the egg industry is the excessive deposition of fat in the abdomen and liver of laying hens, and the associated fatty liver syndrome. We can reasonably ask 'What is the cost of this excess fat and can we achieve equal production without it?' A certain amount of fat is required for yolk production, but is it possible to direct more of the liver deposits directly to the ovary and at the same time reduce the amount of fat stored in the liver and abdomen? Much work has been done in this area and it would appear that fat production in the laying hen is aberrant, although the cause is not yet obvious. Several nutritional and management practices have been applied to this problem with varying degrees of success. A better knowledge of the physiological reasons for aberrant fat production would enable a more reasonable approach to the development of methods for controlling fatty liver syndrome.

Research category —Medium priority, 10-year study.

Layer Flock Health

A report by J.R. Pettit, Animal Diseases Research Institute, Agriculture Canada, Ottawa.

The efficient production of eggs by the modern poultry industry given the large flock sizes, confinement rearing and high stress environments would not be possible without the steady improvements that have been made in the area of poultry health. Many of the 'natural' diseases of chickens which plagued the industry in its early days have been eradicated or are controlled by vaccination, therapeutics, or modified and improved management techniques. Diseases such as fowl typhoid, pullorum disease and tuberculosis have been eradicated from the commercial industry. Viscerotrophic velogenic Newcastle disease and fowl plague, although a problem in other parts of the world, are no longer present in Canadian domestic flocks. However, continued vigilance on the part of the veterinary profession and the industry at large is essential in maintaining this satisfactory situation.

Coccidiosis in replacement pullets raised on litter has been well controlled by a variety of coccidial-inhibiting drugs and improvements in management procedures. However, these procedures are costly and must be maintained if outbreaks of this serious disease are to be prevented.

Many of the serious diseases of poultry are caused by viruses and are controlled, with some significant exceptions, by vaccination. Many of these procedures are carried out during the starter pullet stage, but a need exists to maintain this protection by periodic vaccination during the laying period.

Eradication, therapy, and vaccination procedures, along with numerous nutritional, management and genetic techniques, have been used to control many disease problems affecting poultry. However, many of the diseases occurring in modern poultry flocks have resulted from failure to use properly the information already available for the prevention of economic losses from disease. Some other recurring problems could be described as 'man-made' disease (e.g., diseases resulting from overcrowding, forced production or inadequate nutritional status possibly in combination with an infectious agent). In this group are new disease situations which emerge because of changing environmental factors. Another and possibly more frightening situation is the ability of some disease agents to adapt to present control measures.

The challenge of disease research in the 1980's will be to develop the techniques to eradicate those diseases still prevalent in Canada; to develop new vaccines and chemotherapeutics for the control of adapting disease agents and to investigate and try to develop control procedures for new disease conditions as they are recognized and when they are found to cause economic loss.

In general, from a disease standpoint, we are in a relatively fortunate position. We can thank the dedicated and close cooperation between all segments of the industry and all disciplines of the scientific community for our present situation. In spite of these encouraging results, we do still have some areas that affect our ability to produce our product efficiently. These will be discussed in this report.

Diseases and Suggested Research Areas

Lymphoid leukosis is a virus-caused blood cancer in chickens. It is a disease affecting birds 16 weeks of age and over, and mortality continues at a low level throughout the life of the flock. It has recently been found that flocks suffering from infections with this virus are less productive and are more susceptible to other disease conditions. In other words, this virus can help other disease agents cause disease. Several procedures are presently available for the detection of the virus in infected

birds. One of the most promising is the application of the complement-fixation test which allows researchers to detect eggs that are carrying the virus. The developments of this and other tests on a commercial scale and the resulting elimination of infected eggs would allow primary breeders to eliminate this agent from their progeny. Since the virus is usually transmitted from the hen to offspring through the egg, it would be possible to obtain layer flocks free of this agent, once the primary breeding stock is free. This would improve livability and productivity. A project is presently under way on this subject and to date the results are encouraging. Some refinement of techniques for large scale testing is still required, but eradication of the disease at last seems possible.

Research into these and other procedures for identifying infected birds is needed as a high-priority item. Control of lymphoid leukosis appears possible in the 1980's.

Coccidiosis is a disease of the intestines caused by a single-celled protozoan parasite. These agents are presently in the environment wherever birds are raised. The close confinement of started pullets or broilers allows this agent to spread easily through a flock and cause devastating losses. There are six species of coccidia in chickens capable of causing various forms of the disease and loss of productivity. At present there are several drugs (coccidiostats) that can be mixed with the feed to prevent outbreaks. Since most layers are kept in cages, it is not necessary for the started pullet to develop immunity to this disease agent. Due to this, coccidiostats are used to prevent infection in started pullets on litter. It has recently been noted that some of the coccidial parasites are developing resistance to common drugs. Projects aimed at the development of resistance are presently under way, but more studies into other coccidiostats and control measures are needed.

This is research of medium priority and likely of long duration because of the continued probability of drug resistance in strains of coccidia.

One of the common causes of a moderate drop in egg production is *Mycoplasma Gallisepticum* infection. This agent usually causes only a mild respiratory disease in mature birds. If the birds become infected with this agent at the time of their peak production or are carrying this agent and undergo a severe stress at this time, a loss in egg production and some mortality may follow. The majority of hatcheries supply MG-free birds. Sometimes these birds become infected during the started pullet stage, but are more commonly infected after they have been placed in a laying house. The disease can spread from an older flock on a farm and cause problems in a younger laying flock. Production may be reduced by 10% and never return to normal. At present there are two main approaches to the problem. Some scientists suggest vaccination (infection) of birds during the started pullet stage in order to prevent them from coming down with the disease during the stressful peak egg-production period. The other method, and in my opinion the best, is to eradicate the agent and prevent it from gaining entry into new production flocks. Research is needed into both these areas in order to clarify the disease situation and to suggest practical solutions for the farmer. There is a research need for quick cultural diagnostic procedures and improvements in the ones we have. It is still very difficult to identify some of these agents after they are isolated. Research into heat and antibiotic treatment of eggs as a method of eliminating this agent may also be useful in control procedures.

Mycoplasma is a high-priority item in research and could be handled in a relatively short time if adequate research was carried out.

Other problems associated with drops in egg production or the production of eggs with poor shells or internal quality are extremely important to the industry. There are many unidentified causes for production drops and there is a need to study them in detail, using a multi-disciplined approach to try and answer some of these questions. Extensive monitoring of disease of laying fowl is essential if newer causes of production drops are to be identified. This is an item of moderate priority and long duration.

It is known that certain diseases (i.e., infectious bronchitis, adenovirus, avian encephalomyelitis and mite infestations) can cause abnormal shells and/or production drops, and other conditions can cause abnormalities of the internal quality of the egg. There is difficulty at present in identifying and differentiating many of these agents as they appear in the field, and additional research is needed into diagnostic techniques for these conditions. In many production problems, no disease agent can be found and nutritional and managemental factors must be considered in order to attempt to sort out the problem. Serological blood testing and virus isolation and identification of infectious bronchitis and adenovirus are extremely complicated. The technology for diagnosis is being developed. This is an area of high priority which will require several years of concentrated research.

At least one of the presently accepted vaccination procedures has been suspected of aggravation shell problems when given to the bird at certain ages. Research is needed into vaccination and other control measures for infectious bronchitis and adenoviruses, and into the development of newer drugs for controlling mites without leaving residues in the eggs. These are research areas of moderate priority and of long duration because of continued needs to stay ahead of mutating viruses or drug-resistant mites.

Another area of serious concern in the area of egg production is the development of *osteomalacia*, or soft bones. The condition results in decreased egg production and weak-shelled eggs. This syn-

drome often occurs early in the production period, causing a severe loss in shell quality and increased mortality in the flock if not treated early. Birds are usually suffering from a calcium depletion. Less commonly, a depletion of phosphorus or vitamin D_3 can be involved in this problem. The initiating cause is not always fully understood. The ration can be adequate but the birds can still develop osteomalacia. Subclinical diseases or genetic predisposition have been suggested as possibilities, but more research into this syndrome is needed. This should be considered of moderate priority and duration.

Another syndrome of unknown cause is the *fatty liver syndrome*. There is a much stronger relationship between the genetic makeup of the bird and this particular syndrome. However, outbreaks of this syndrome, with its related internal hemorrhage, mortality and decreased egg production, have occurred without a clear-cut relationship to bird type. Mycotoxins, subclinical viral hepatitis and nutritional imbalances have been suggested as potential causes. Investigations into this syndrome have been carried out in the past, but there are still areas, especially as they relate to fungal toxins in the feed, that need more investigation. This would be considered a relatively low-priority item at present.

Another very common reason for death loss in layers is *cannibalism*. This could be related to poor debeaking, overweight birds, genetic suscetibility, unidentified nutritional factors or improper lighting and heating. Investigation into these parameters could be carried out as a low-priority item.

Pasteurella multocida is a bacterial organism that can cause severe peritonitis, hepatitis and repiratory tract infections in layers. *Pasteurella haemolytica* is another agent capable of causing these types of problems. Both organisms can cause very high mortality in a flock if not treated promptly with antibiotics. The problem is that eggs from a flock being treated cannot be used for human consumption because of potential allergic reactions in humans and the development of drug-resistant bacteria in human intestinal flora. The cost for treating this or other bacterial diseases with antibiotics is threefold: loss of birds, cost of drugs, and loss of egg sales. There are bacterins and vaccines on the market for these agents, but improvements are still required in their application to the layer flock. Research into control measures are needed for these and other bacterial diseases of birds as a moderate-priority items. This will be a long-term project.

Other bacterial diseases of layers such as infections coryza, listeriosis, staphylococcosis and colibacillosis are much less common but have the ability in individual flocks of causing mortality or production loss. They are, like Pasteurella infection, difficult to treat because of antibiotic residues in the eggs.

Infectious laryngotracheitis is a virus-induced respiratory disease of chickens and pheasants. It can cause severe respiratory distress and moderate production loss in layer flocks. Mortality can be significant if other disease or poor management conditions are present. The disease has occurred on two occasions in Ontario in the 1970's and has been a continuing problem in commercial flocks in British Columbia. It is very common in small hobby flocks. Vaccination of individual birds by the eye drop method is effective in stopping outbreaks. The inconvenience and undesirability of handling egg-producing birds individually make research into the development of better vaccines a high priority. If a vaccine could be used effectively in the drinking water or as a spray, much of the expense of this disease problem would be eliminated.

Infectious laryngotracheitis is an example of an area of concern with vaccines and vaccination programs. Although the desease can be held in check by vaccination, the techniques so far developed leave much to be desired. There is need to improve methods of vaccine delivery, and to develop milder vaccination agents and wider spectrums of protection against agents such as infectious bronchitis where several types of virus exist. Recent reports of outbreaks of Marek's disease in Georgia in birds that had been properly vaccinated are associated with the identification of a new Marek's agent capable of over-riding the turkey herpes virus vaccine and help to reinforce our concern in these areas of vaccine development.

This area of research into vaccine improvements is high priority and of a long duration.

Marek's disease is another virus-induced blood cancer of birds that for many years was the number one disease problem affecting layers. Since the development of the vaccine in 1970 we have had good control of this disease. There is still work to be done in genetic selection and in the development of better delivery systems for the vaccines (e.g. the aerosol route of vaccine administration). This could be considered of medium priority.

Other areas of poultry disease research—ones which are not directly related to poultry production but which are important for the establishment of an animal model of human disease—must be continued in order to expand our knowledge of human diseases. For example, mention could be made of the study of the virus-induced cancers of birds which is leading to an increased understanding of leukemias in humans and other mammals. The studies of immunosuppressive diseases, such as Marek's disease and infectious bursal disease, are others that helped to discover the functioning of the immune systems in higher animals. The recent discovery of a Marek's virus-induced arteriosclerosis of birds similar to that occurring in humans may also be an example of a future animal model for the study of human disease. These areas of research will remain high-priority items for studies on diseases of humans, but should not be ignored by

poultry pathologists.

As stated earlier, the disease situation in laying flocks is fairly good. This does not mean we should disband our diagnostic or research facilities; we still have problems to deal with now and, in all probability, there will always be new conditions occurring for which we will need the expertise that we have developed in our veterinary research and diagnostic communities over the years.

Disease control then, depends on a strong regulatory effort by Agriculture Canada in order to keep eradicated diseases out of Canada. It depends on adequate diagnostic facilities to identify disease outbreaks and solve them with minimum financial loss. Disease control also depends on an energetic research community willing and able to respond to industry needs and to those of the diagnostic laboratories. It depends on strong emphasis being placed on poultry in the veterinary and agricultural colleges in order to supply enough competent people for the 1980's and beyond. Disease control also depends on poultry managers and farmers who can continue to produce an extremely nutritious product at an economical price and who will continue to realize the importance of research into all aspects of their business.

Pullet and Layer Flock Management

A report by A.T. Hill and J.R. Hunt, Research Station, Agriculture Canada, Agassiz, B.C.

There are two main reasons for starting this report on pullet and layer flock management with production costs. A knowledge and control of these costs is vital to the success of the business and this is the first reason. The second relates more specifically to this conference. One of the purposes of this meeting is not only to identify areas requiring further research, but also for participants to attach priorities. One of the ways of doing this is to determine the relative financial benefits, or conversely, the losses that could be avoided were certain improved management procedures discovered and implemented. To assist in this, Tables 9 to 11 have been prepared on the cost of pullets, the cost of a dozen eggs and the relative loss from undersize and undergrade eggs.

The current cost in British Columbia of producing a 20-week-old pullet was taken because of the availability of reliable and up-to-date information. Buildings were written off at 5% per year and equipment at 10%, to obtain the depreciation cost per pullet of 10.6% (Table 9). Of the 17.9% for overhead, interest charges on long-term debt and working capital accounted for 10.0%. On this basis, the 10.6% depreciation cost plus 10.0% for interest added up to 20.6% of the total 140-day pullet cost, a figure equal to the day-old chick cost itself.

Turning to the producer egg production costs for Canada (Table 10), it is to be noted that feed costs are now under 60%. Depreciation and interest costs amount to 4.1% and 3.2% respectively.

Of the more than 350 000 000 dozen eggs received annually at grading stations in Canada, 5.9% are in grade B and C categories (Table 11). Most of these eggs are large. Were they Grade A,

TABLE 9. Cost of 20-week-old Pullet in B.C.—July 1979

Item	Cost/pullet $	%
Depreciation		
Buildings & equipment	.28	10.6
Pullet cost (allowing for 2.5% mortality)	.53	20.4
Feed cost	1.25	47.7
Winter (1978-79) $1.28		
Summer (1978) $1.17*		
Labor		
Management & labor	.09	3.4
Overhead		
Plant operation & interest charges	.47	17.9
Total	2.62	

* Including recent price increases

TABLE 10. Producer Egg Production Costs for Canada—April 16, 1979.

Item	¢/dozen*	%
Depreciation		
Buildings & equipment	2.57	4.1
Pullet costs		
Price minus salvage value	11.49	18.6
Feed costs		
Cost times feed conversion	36.17	58.4
Labor		
Management & labor	5.16	8.3
Overhead		
Plant operation & interest costs	6.55	10.6
Total	61.94	

*Based on 20 dozen eggs produced per pullet per year

TABLE 11. Grading Station Results for Canada (1978) and the Relative Loss from Undersize and Undergrade Eggs

Grade and size	%	Loss relative to Grade A Large eggs %
AEL and L	62.2	
AM	25.7	
AS	5.5	
APW	0.7	
B	1.9	
C	4.0	
B and C	5.9	3.3
AM, AS and APW	31.9	5.9

returns to producers would have been increased by $7 500 000. Studies at Agassiz, where samples of eggs have been regularly graded, show that these undergrades consist of about 2.6% with rough shells and poor texture, 1.3% with poor albumen quality and 2.0% with both inadequacies. Undoubtedly the 31.9% of the Grade A eggs that do not rate as large-sized will be further reduced by the foundation breeder. However, it would seem that the biological capacity of layers to produce 2-2¼ ounce eggs is being reached. Possibly the efforts of the breeders should be directed more toward mass of eggs and that eggs should be marketed by weight, as appraised by Thompson and Cheng (1978).

Egg Quality

Shell

There is no doubt that, after disease, poor shell quality causes the greatest losses in the net returns of an egg production unit. Estimates of losses in Canada due to shell quality range between $6 000 000 and $7 000 000 annually.

Research workers have been concerned with the shell problem for more than half a century, but progress has been slow because the subject is complex. Scientists have long known the inheritance of shell quality, but the need to select for other factors at the same time has reduced the selection pressure. Since age of bird is of major significance, the geneticist must consider eggshell quality over the entire laying year. Also, environmental temperature and even the time of day when the egg is laid have a marked influence, thus making genetic selection even more difficult. Nevertheless, advances in basic knowledge of eggshell formation have progressed well in the last 15 years despite the fact that the organ of interest is deep within the body cavity.

Presently, research is under way at the Animal Research Institute in Ottawa where a team is working on this problem, looking at both the genetics, physiology and measurement of shell strength. The University of Manitoba is investigating the effect of fluorine on shell quality, the University of Guelph has long had an interest in the problem and the Kentville Research Station is examining the effect of pre-lay nutrition on eggshell quality. Because of the difficulties of working with shell-strength improvement, most of the other poultry research establishments work on it sporadically as ideas and resource funds allow, although they have a strong interest in the problem. For example, the Agassiz Research Station is working on factors related to shell texture and the value of a vitamin D metabolite. Lethbridge is concerned with the effects of water quality on shell strength.

For the person concerned with the management of a laying flock, there appears to be a need for intensive research in eggshell quality. It has been shown in England that the stance of the hen when laying an egg has a marked influence on the percentage cracks and this has been related to the flexibility of the cage floor. However, there has been no change in the floors of commercially available cages. The need to reduce losses at this point through further research is evident. Similarly, shell research that leads to a greater impact resistance will be of immense value to the industry the world over. It is recognized that basic research and its practical application is needed to solve the cracked-egg problem.

Shell texture and misshapen eggs are significant problems in maximizing net returns. Dietary factors appear to be responsible for shell texture. On checking a commercial product that claimed to reduce percentage cracks, research workers at Agassiz found that neither the breaking strength nor the specific gravity of the eggs was improved with the product, but there was a marked improvement of shell texture as rated on a visual score. It is thought that the improved shell texture, not eggshell strength, resulted in a reduction of undergrades. The real need in shell texture research is to develop a non-judgmental method of assessing shell texture so repeatable observations can be made.

Misshapen eggs appear to be associated with periods of high egg production when more than one egg is laid each day. This problem appears to be one where genetic selection will make the most advance. However, the other disciplines should not ignore its existence.

The use of ahemeral (non-24-hour) day lengths to improve shell quality in the latter part of the production cycle, as shown by Leeson, Summers and Etches (1979), has provided an interesting approach and should be investigated further.

It is known that temperature affects eggshell strength; with an elevated temperature of the egg, resistance to damage is lowered. However, it is not known if the costs of extra handling to cool the eggs

prior to cleaning and traying for shipment warrants this procedure on the farm.

Research on egshell strength, with the aim of reducing losses due to breakage, must take a coordinated, multidiscipline approach. This need not require a 'team' at one location, but it calls for active interchange of information on a nationally coordinated basis. The problem is economically important enough to the industry that this research be coordinated nationally. The difficulty of working on this problem also dictates the need for full cooperation.

Albumen

It has long been documented that age of bird, temperature of storage, strain, and oiling clearly influence the albumen quality of fresh and stored eggs. Furthermore, it is recognized that oiling is no substitute for cool room storage as a means of slowing deterioration of albumen quality. Also, washing need not necessarily increase the degree of deterioration in albumen quality or increase bacterial growth during storage. Several investigators have shown that strain differences in the quality of fresh-egg albumen do occur, but these tend to disappear over extended periods of storage. While all of these experiments contributed materially to the understanding of retention of albumen quality during storage, few examined the effects of the combination of treatments that eggs are subject to when moving from the producer to the consumer.

At Agassiz, four experiments were conducted with 37 different combinations of oiling, washing, and sanitizing at various times in an attempt to measure these effects upon albumen storage quality (Hill and Hall, 1979). Increases in storage time and age of layer cause a decline in Haugh units and an increase in their variability (Table 12). Losses during the first 48 hours after lay were particularly heavy. Oiling on day of lay at least halved the loss in egg weight and lowered Haugh unit losses during storage. Washing by itself had no effect but if practiced before oiling, reduced the benefits of oiling when eggs were stored 14 days. Re-oiling after washing at 3 days tended to improve the Haugh units in eggs stored 7 and 14 days. Combinations of oiling, washing and sanitizing did not increase variability in Haugh units in storage. Oiling on day of lay and subsequently washing, sanitizing and re-oiling were the best treatments for the retention of Haugh units during egg storage.

Because of the difficulty of removing all actual and anticipated undergrade eggs with today's mass-candling procedures, coupled with the grading station manager's need to meet the date-stamping requirements of the Canada Food and Drug Regulations, a further study was undertaken. Due to the lack of information (Heath and Owens, 1978 excepted), emphasis was placed on the measurement of the quality variability of fresh and stored albumen and on determination of sample sizes of eggs needed to spot-check this quality. With the cooperation of the British Columbia Ministry of Agriculture's Poulty and Veterinary Branches, Agriculture Canada's Food Production and Inspection Branch and the British Columbia Egg Marketing Board, eggs handled under simulated commercial conditions during 13 separate 28-day periods and stored from 1 to 26 days, were measured from eight commercial strains. It was concluded that, on an average, eggs oiled as laid from flocks 28 to 48 weeks of age hold their Grade A albumen quality for approximately 26 days, those from flocks 52 to 68 weeks of age for 19 days, and those from flocks 72 to 76 weeks of age for 12 days. However, achieving this level of albumen quality in each egg marketed calls for the removal of some eggs in the grading station with Haugh units several points higher. Fresh-egg value from layers 36, 56 and 76 weeks of age were essentially the same at the 67-69¢/dozen when Grade A Large eggs were 71¢. However, stored 5 days, these eggs dropped 3, 6 and 12¢/dozen respectively, due to the albumen quality decline (Table 13). Similar values after the 19-days storage were 5, 20 and 29¢. Oiling the eggs as laid drastically reduced these losses to 1, 1, 2, 2, 7 and

TABLE 12. Effect of Age of Layer on Average Egg Weight, Haugh Unit, Egg Value Unit Variability

	Age of layers (weeks)						
Trait	26-30	34-38	42-46	50-54	58-62	66-70	74-78
Egg weight (g)	54.6	58.6	60.6	61.2	62.4	62.8	62.8
Haugh unit	82.0	76.0	75.9	74.4	75.7	73.8	74.0
Egg value (¢/dozen)	62.8	61.6	63.8	63.0	64.8	62.0	61.1
Haugh unit standard deviation	5.9	6.8	6.4	6.5	6.6	6.8	7.6

TABLE 13. Oiled and Non-oiled Egg Values (¢/dozen) Decline With Advancing Age of Layer and Days of Storage (Based on Albumen Quality)

Age of layers (weeks)	Treatment*	Fresh egg value	Decline from fresh egg value (¢/dozen) Days of storage 5	12	19	26
36	NO	67	3	4	5	8
	O		1	1	2	4
56	NO	69	6	9	20	27
	O		1	1	7	10
76	NO	68	12	22	29	31
	O	68	2	5	8	13

* NO—non-oiled; O—oiled.

8¢ respectively. Oiling eggs as laid has a relatively greater benefit on the value of eggs stored briefly than those stored for 19 and 26 days.

The estimated number of eggs to be sampled to obtain Haugh units with reasonable accuracy on days 1, 7 and 14 ranged from 20 for young pullets to 30 for old hens. Samples of 50 eggs, taken on day of lay, were required to predict 7- and 14-day Haugh units with the same precision. Strain of bird had no material effect on those sample sizes. It was noted that yolk mottling in non-oiled eggs from birds 60 or more weeks of age can be a problem when stored for more than 12 days. This was reduced by almost a half when the eggs were oiled as laid. Heath and Owens (1978), Sabrani and Payne (1978), Stewart and Montgomery (1977) and Tanabe (1978) have also recently reported on some of the factors affecting albumen quality. In the main, all results are quite similar. Moats (1978) also reviewed the effects of egg washing.

There is need for further research. It would seem from Hyde's CEMA Egg Quality Committee report (1978) that, in general, most customers today are indifferent to albumen quality. This being the case or until a broader-based Canadian study shows that customers are concerned, it would seem that in terms of both regulations and research, there should be a de-emphasis upon albumen quality. In the meantime, there is adequate information to sample poor eggs with poor albumen quality at the grading station and to channel them directly to the breaker.

Cage Design

Pullet

For a variety of reasons, the brooding and growing of pullets in cages is an accepted alternative practice to floor rearing. At Agassiz, the subsequent laying house performance has been equal for pullets raised in cages or in floor pens, provided that adequate floor, feeding and watering space have been provided in the growing cages. Current studies at the B.C. Poultry Branch Station show that 22 pullets at 45 sq. in./bird and 18 pullets at 55 sq. in./bird had equal livability and similar body weight. With the 22 and 18 pullets in the 24′ × 41′ commercially manufactured cages, 63.0 and 65.3% were within ± 10% of the average weight at housing, somewhat below the goal of 70%. Undoubtedly the housing of pullets by weight categories could advantageously be practiced more widely. One concern with cage-reared pullets is that they tend to be more nervous and flighty. However, when housed 2-4 per laying cage with 60-84 sq. in. respectively per pullet, these birds settle down and become excellent layers. The use of similar feeders, and particularly waterers, is very important in the changeover.

Further research is needed. The fact that cage rearing is a relatively new practice means that many new improvements can be invented. Particular emphasis needs to be placed upon the economics of pullet housing as cages tend to add further to the cost of pullet replacement.

Layer

Minimizing capital, labor, equipment and shell breakage and maximizing egg returns over feed and bird costs, consistent with maintaining bird comfort, have been the objectives of intense investigations in at least six institutions in various parts of the world over the past 10 years.

Elson (1976) at Gleadthorpe in Britain and Rose-Marie Wagner *et al.* (1978) at Celle, West Germany, have been steadily improving get-away cages. These cages with their roosts, feeding and watering stations at three heights provide more vertical and horizontal space per bird and cater to birds at the lower end of the peck order. However, they have yet to be proved economically sound. Furthermore, the placement of layers in small populations in more-conventional cages will probably provide most of the benefits of get-away cages.

Elson (1976) tested a very wide variety of wire floors and showed that (1) 25-mm wire netting at 11½° slope, (2) 25-mm wire netting at 13½° slope, (3) 25-mm × 25 mm welded wire at 7½° slope and (4) 25 mm × 25 mm welded wire at 9½° slope performed equally well and yielded the lowest percentage of cracks, dirty eggs and eggs on the manure belt. 50 mm × 25 mm welded wire at 7½° slope yielded a slightly higher level of cracks. All wires were 14-mm gauge. In Maine, Muir (1976), using Red × Rock layers, found no difference in performance in cages 12 and 14 inches high at the back of the cages.

Since the study by Elmslie *et al.* (1966), scientists and the egg industry have come to realize that both cage floor space per layer and population number must be considered simultaneously. Hughes and Black (1976), Lee and Bolton (1976) at the Poultry Research Centre, Edinburgh, Muir and Gerry (1976) in Maine, Bell (1972) in California, and Sefton and Crober (1976) in Nova Scotia are among those who have made valuable contributions in determining the optimal combinations. Concurrently and in consultation with these people, studies at Agassiz have been conducted. The philosophy has been to design laying cages that provide the environment in which the layers can best express their genetic potential. While it is true that our cages have not in effect varied greatly from those provided by cage manufacturers, we have usually constructed our own.

The results in Tables 14 and 15 show the trends that were clearly apparent in seven experiments with 19 328 pullets housed over the past 10 years at this station. With the exception of the first experiment, all pullets have been purchased from commercial hatcheries and represent the Leghorn-type and one brown-egg producing stock. Eggs were credited with 70¢ per dozen Grade A Large, pullet costs at $2.50 and feed at $150 per ton. We have presented the results in Table 14 in terms of per-pullet housed and in Table 15 on the basis of the use of 144 sq. in. of floor space.

TABLE 14. An Estimate of Annual Egg Returns ($/bird) Over Feed and Bird Costs in 24-cage Population Size—Density Combinations

Space/bird sq. in.	Number of birds in cage: 2	3	4	6	8	12	Average
48	1.02	.94	.90	.85	.74	.65	.85
60	1.60	1.42	1.30	1.15	1.05	.98	1.25
72	1.85	1.61	1.45	1.25	1.15	1.09	1.40
84	1.93	1.71	1.55	1.35	1.26	1.20	1.50
Average	1.60	1.42	1.30	1.15	1.05	.98	1.25

As might have been expected, net egg returns over feed and bird cost, on a per-pullet housed basis, declined with increasing populations in a cage and decreasing space per bird. That the effects of population size alone cannot be examined without regard to space per bird, as had been done in most experiments prior to 1970, is shown clearly in Table 14. The differences in net egg returns between populations of 2, 3, 4, 6, 8 and 12 are very different at 48 sq. in. per bird than at 84 sq. in. The fallacy of placing an extra pullet in a cage is also clearly illustrated by comparing the $1.85 return per bird with 2 birds at 72 sq. in. per bird and the 94¢ return per bird with 3 birds at 48 sq. in. per bird. Even when compared on the basis of the use of 144 sq. in. of floor space (Table 15), the 2 birds together yielded $3.70 and the 3 birds together only $2.82 net egg income.

Considering the traits which contribute separately to net egg returns, livability followed the same trend. Two birds per cage, each with 60, 72 and 84 sq. in. per bird; 3 birds with 72 and 84 sq. in., and 4 birds with 84 sq. in. per bird tended to lose less than 1% per month. Whereas space per bird had no consistent effect, there was a significant increase in feed consumption per bird with increasing population size. This was attributed to the significant increase in nervousness and activity of the layers. Richards (1977) has shown that feather covering has a real influence on heat output and thus utiliza-

TABLE 15. An Estimate of the Annual Egg Returns Over Feed and Bird Costs ($) for 24-cage Population Size—Density Combinations Based on Use of 144 Sq. In. of Floor Space

Space/bird sq. in.	Estimate based on on the use of sq. in.	Number of birds in cage: 2	3	4	6	8	12	Average
48	144	3.06	2.82	2.70	2.55	2.22	1.95	2.55
60	144	3.84	3.41	3.12	2.76	2.52	2.35	3.00
72	144	3.70	3.22	2.90	2.50	2.30	2.18	2.80
84	144	3.31	2.93	2.66	2.31	2.16	2.06	2.57
Average		3.48	3.10	2.84	2.53	2.30	2.14	2.73

tion of energy in the feed. Egg production also followed the same trends as net egg returns.

These results have led us to recommend three Leghorn-type layers each at 72 sq. in. per bird and if a fourth bird must be placed in a cage, allow 84 sq. in. On very meagre evidence, an extra 12 sq. in. per bird is recommended for hens producing brown-shell eggs.

More recently, layer cage orientation has received a lot of attention (Bell 1978). For example, the dimensions of the traditional 12-inch wide by 18-inch deep cage have been switched to create an 18-inch wide cage with a 12-inch depth. Cages like this are known as reverse or shallow cages. Noteworthy is the increased feeding space and shorter distance eggs have to roll.

Bell *et al.* (1979) stated that shallow cages yielded significantly higher monetary returns with the same floor space per bird than did deeper cages. At Agassiz, layers in shallow cages have consistently eaten more feed and frequently laid larger eggs. In contrast, Agassiz layers in shallow cages have had equal or poorer egg production, the same number of cracks and equal or poorer net egg returns over feed and bird costs. The birds have also been more nervous and lost more feathers.

These results have led to our recommendation that traditional deep cages not be hastily and prematurely scrapped. However, if new cages must be installed and in spite of the Agassiz results, it is recommended that the use of shallow cages be very carefully considered. This is suggested because (1) partitions can be more readily placed in shallow cages to reduce the size of the population per cage and (2) space can be provided so that all birds can eat at the same time. One possible disadvantage of shallow cages is the need to provide more tiers to house the same number of layers. The higher tiers can sometimes be harder to reach and manage. However, with the trend towards feeding chains and other systems of restricting the time and quantity of feed that is available to layers, the provision of adequate feeding space for all birds at any one time becomes increasingly imperative. In these shallow cages, current studies at Agassiz and earlier ones by Bell (1978) suggest that two birds at 60 sq. in. per bird is the optimal combination, based on per bird housed and use of a given volume of laying house space. Three birds with 72 sq. in. per bird is the next best combination on a per bird housed basis.

More research is needed because cage density, population size and orientation investigations to date have usually been conducted where the feeding has been continuous and manual. With industry already using automatic feeding systems and slant back cages, with and without quantity and time restrictions, there is a very real need to reevaluate these cage systems. Methods of preventing feed ingredient separation with feed restriction should also be incorporated into these tests.

Restricted Feeding

Pullets

The benefits resulting from restricted feeding of growing pullets have been well researched by Gowe and co-workers. This management practice has been replaced by light control and today few pullets are reared on a restricted feeding program. Pullets are often restricted, but this is mainly due to overcrowding in rearing cages and results from poor, rather than good, management.

Layers

Restricted feeding in the laying period is a management tool that can effectively increase returns. With the narrower egg returns in the United States, it is practiced more widely there than in Canada. Research at Agassiz has demonstrated that restriction at 90% of full feed in the last two thirds of the laying year has no effect on egg numbers and that the effect on egg size does not influence egg returns. Level of energy of the diet did not influence the response to restricted feeding. However, it is imperative that a control group on full feed be used to gauge feed intake as it is too variable a factor to apply a standard feeding rate for the production year.

The need for further research in this area appears to be in the area of restricted nutrients rather than total feed. As feed costs rise, and they are the largest cost component of production (Table 10), the question arises as to whether or not full nutrient intake in the most economical system for egg production. Under what cost conditions would it be more economical to feed 80 or 90% of requirement rather than the current practice of supplying at least 100% and usually 120% of actual needs? Energy is the exception to this statement as layers usually limit according the energy intake. When soyabean went to $600/ton it was more economical to produce broilers on a lower-protein feed. Will the same principle apply to layers? These answers should be available before they are needed and it is essential that these studies be done in cooperation with agricultural economists.

Choice and Timing of Replacement Program

The two principal flock-replacement programs that can be used are (1) annual replacement and (2) replacement after 1½ or 2 years, depending on force-molting the flock once or twice. The principal advantages of force-molting are the lower monthly pullet depreciation costs and larger egg size. Offsetting these are the lower egg production, poorer egg

quality and an increase in the months of non-productive occupation of the laying facilities with their relatively fixed depreciation and overhead costs. The length of time birds are in lay in both programs is another very important factor.

Annual Replacement

Higher egg production and better shell and albumen quality are points in favor of early replacement of hens. Offsetting these advantages are the smaller eggs and higher pullet inventory costs. Results at Agassiz with two flocks, each of 2000 White Leghorns of two commercial strains (Hill, 1977), show that flocks should be replaced after no more than 12 months of lay (Figure 1). When egg returns, relative to feed and bird costs, are high, replacement should take place after 11 months of production and 13 months when the reverse is the case. Changes in depreciation for buildings and equipment and interest costs merely change the margin of profit and do not materially alter the optimal time for flock replacement. The significance of undergrade eggs with months of production shows in the graph.

water and 7 pounds of mixed grains per 100 birds. The use of the anti-ovulant drug ICI 33828 also stopped production, but the use of Gilbert's (1973) minimal calcium program was not successful. The complete cessation of production was vital to the successful conditioning of the hens for their second period of lay. It was further shown that a 3-week rest period was optimal, 2 weeks was inadequate and 4 weeks gave marginally better results. However, the improvement after 4 weeks was not sufficient to offset the added house and equipment depreciation and overhead costs. Optimally, the hens reached 50% production 7 weeks from the start of the force-molt program.

More-recent studies by Swanson and Bell (1974) have shown that to derive the maximum benefits, force-molting should be carried out long before the layers are spent from their first year's lay. Molting after 8 months of lay has proved to be best. Sometimes it is advantageous to follow this with a second molt after a further 6 months of lay. Simple methods of molting have been found as effective as more complicated ones. The University of California recommendations are (1) reduce day length to 8 hours, (2) withhold feed for 10 days but provide access to water at all times, (3) feed cracked grain

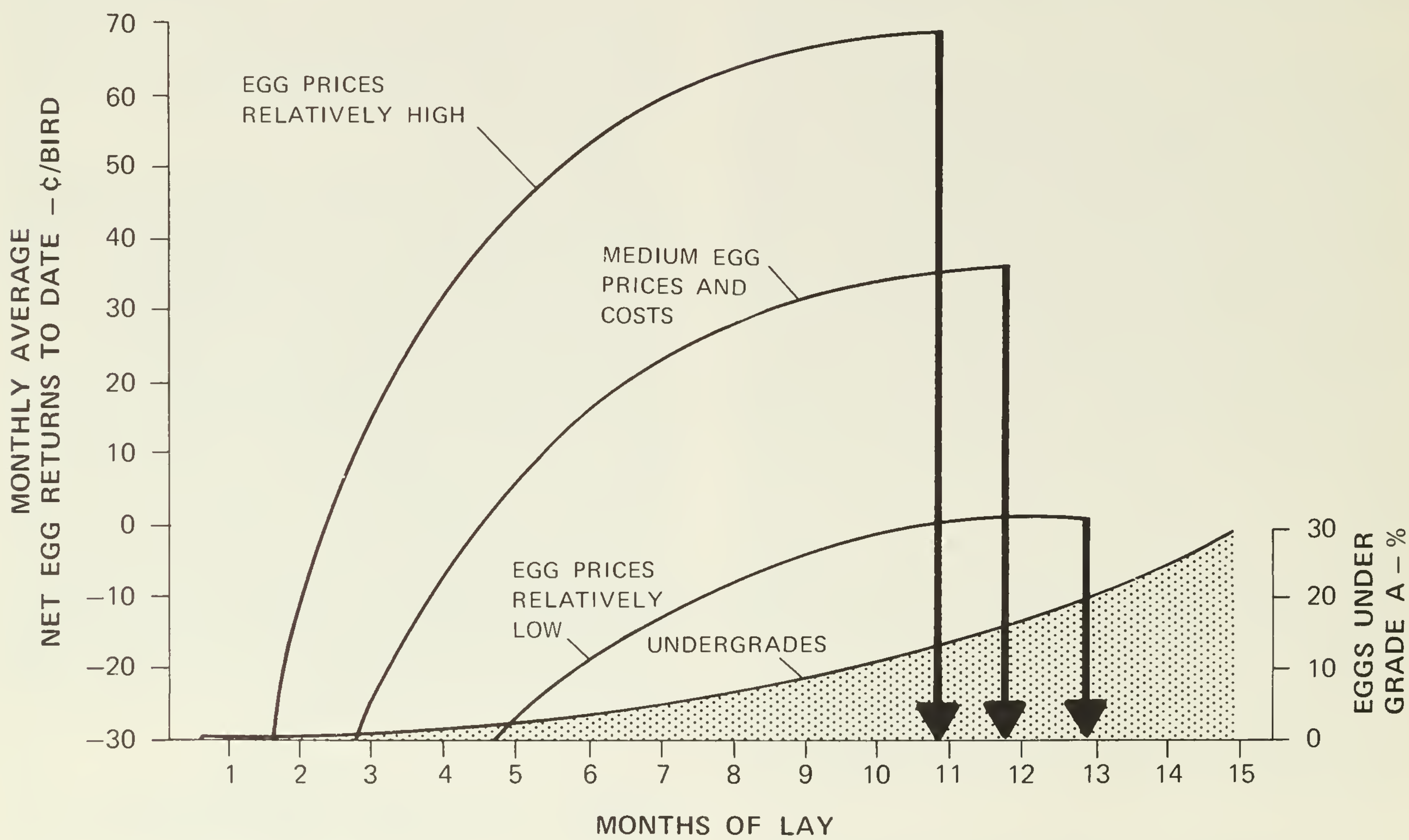

FIGURE 1. Optimal age to depopulate layers

Replacement After Force-molting

Early work at Agassiz showed that layers, after 12 months of lay, could be force-molted by a program of no feed or water for 3 days, followed by

for 2-3 weeks to hold birds out of production and (4) return to a regular lighting and feeding routine.

Studies of the economic benefits of force-molting have been few and quickly become out-dated because of the fast change in the relative prices of

feed, pullets, labor, depreciation and overhead. Parlour and Halter (1970) noted that historical evidence indicates that force-molting policies have not found wide acceptance. This was attributed to a lack of reliable information and, more significantly, to an inherent aversion to risk on the part of poultry producers.

More recently, Bell and Adams (1978) at the University of Southern California developed a computer program designed to determine an optimal overall replacement policy for an egg-production firm. It assumes that a producer has more than one flock and that a continuous form of operation is maintained. By November 1978, the input data of 25 firms with and without force-molt programs, representing 10 000 000 layers, had been analyzed. With their original program the anticipated profit was 44¢ per hen. With the best of the 308 alternative programs, this profit, based on past performance data, could be increased to 63¢. Most of these programs incorporated force-molting. The 1978 San Diego survey showed the percentage cost of producing a dozen eggs to be: depreciation, 3.6; labor, 8.5; overhead, 8.3; pullet costs, 12.4, and feed costs, 67.2. Since depreciation, labor and overhead were essentially the same as that for Canada and the relative pullet prices were actually lower (Table 10), it would seem that force-molting in Canada bears retesting. Possibly a Canfarm computer program could be developed to help producers make these flock-replacement decisions.

Lighting

Intensity

It is generally agreed that a lighting intensity of 0.5 foot candles is adequate for pullets to 20 weeks and an intensity of 1 foot candles is adequate in the laying house. Fluorescent lights are more efficient than incandescent lights, but usually cannot be suspended high enough to avoid too-high intensity over the birds. Thus 25-watt or even 15-watt incandescent bulbs with reflectors are used. Higher wattage bulbs are sometimes used and their light intensity and energy usage reduced with a rheostat when not attended.

Duration

The common practice is to have the lights on for 24 hours when the pullet chicks arrive. Thereafter, the lights are frequently on for varying hours until 12 weeks, and for 8 hours a day thereafter to 20 weeks. In the laying house the 8-hour period is frequently increased by 15 minutes per week until 14 hours is reached. Recently these hours of light have been broken down into intermittent periods of light and dark. In tests with pullets of 3-20 weeks of age, Snetsinger *et al.* (1979) reported that the birds had equal body growth on less feed and electric power usage when the lights were on 15 minutes (L) and off 45 minutes (D) for each of eight light hours. The institution of the 15L:45D program for 15 light hours at 20 weeks slightly depressed egg production and egg weight but improved feed efficiency. A delay in implementing the 15L:45D program until 37 weeks led to improved feed efficiency and reduced power without loss in egg production. It was pointed out that management challenges were created, but with planning these can be overcome. No doubt further refinements will be forthcoming.

Heat for Brooding Chicks

Normally chicks are started at 32-35°C the first week and the temperature is gradually reduced by 3°C per week to approximately 21°C. This is provided to the birds' immediate surroundings in coolroom brooding or to the whole house in hot-room brooding. The heat is provided by hot water, hot air, gas or electric space heaters, radiant heaters, etc. To further conserve heat, areas restricted to the immediate needs of the chicks are frequently curtained off with insulated partitions. With good management, all provide a good temperature environment for the growing pullets. Further research is needed in this area. Although the costs of individual heating units can sometimes be obtained, very little information exists on the comparative fuel, equipment, and depreciation costs of the various systems. Nor have serious attempts been made to recapture exhausted heat. There is a very real need for this information.

Waste Management

This has been an industry problem, and for some it still is, but the deep-pit or high-rise type of structure has been extremely effective in producing a waste product that can be handled as a relatively dry product. Extremes in temperature are not a factor, so the principle applies nationally. Obviously this system cannot be applied to older buildings, so the industry is not free of problems.

There is a need to continue research on the production of methane gas from poultry waste. The University of Manitoba has done extensive work in this area, but further refinements are required. There is a need to determine if thermophilic digestion and the methane process can be coordinated to allow the thermophilic process to serve as the heat source.

Where manure is held in a high-moisture state for periods of time, fly populations require control. The total answer to control is not available and requires further investigation. From a logistics

approach, control of the water content would appear to be the most economic aspect to consider.

There is little disagreement in the scientific community that poultry wastes should be returned to the land. Even British Columbia, with its very low percentage (about 2%) of arable land and with almost its entire poultry industry located in the Fraser Valley, experiences no difficulty in putting poultry wastes on land. Special situations will always exist, so the industry needs the capability of coping in this area.

Further utilization of poultry wastes by passing them through ruminant animals has been well investigated. This form of utilization appears to be held back by the drug contamination problem, with a solution appearing to rely on inexpensive assay procedures. Pressure to develop these inexpensive assays appears to be light.

Urban pressure probably dictates that fly and odor control deserve top priority in this area of research.

General Comments

In the area of management, two distinct trends are clearly emerging. They are:

- It is becoming increasingly difficult for public institutions to fund research investigations that are large enough to simulate commercial conditions.
- Strains of commercial Leghorns are being developed that require modified management, lighting and feeding programs (North, 1979). The foundation breeders are also simultaneously providing very excellent guides for servicemen and producers for the optimal management of their birds. It is unfortunate that the results on which their recommendations are made are not usually published. Doing so would enable scarce public funds to be used for research in other vital areas. If nothing else, the two trends emphasize the need of both public research institutions and foundation breeders to collaborate even more closely than in the past.

Management Concerns

The following is a summary of the major management concerns, with order of priority:

- Shell quality —production of adequate shells
  —avoidance of breakage from hen to consumer
- Feed efficiency—energy, protein and quantity of restriction for pullets and layers
- Cage design —for pullets and layers automatically fed
- Energy conservation maximization
  —brooding systems
  —lighting systems
- Economic feasibility of force-molting of layers

References

Bell, D. D. 1972. Reverse cage demonstrates striking income advantage. Poultry Digest 31: 326-328

TABLE 16. Institutions in Canada Conducting Pullet and Layer Management Investigations

Name of institution	Cage shape and size		Egg quality		Egg compos-ition	Dubbing, debeaking and toe clipping	Lighting	Feeding	Fly	Random sample testing
	Growing	Laying	Albumen	Shell						
University of B.C.								x		
B.C.M.A., Abbotsford, B.C.	x					x	x		x	x
Federal Research Station Agassiz, B.C.		x	x	x				x		
University of Alberta								x		
Provincial Test Station, Oliver, Alta				x				x		
Federal Research Station Lethbridge, Alta				x				x		
University of Saskatchewan				x						
University of Manitoba				x				x		
University of Guelph				x	x		x	x		
Animal Research Institute, Agriculture Canada, Ottawa				x				x		
Food Production & Inspection Br. Agriculture Canada, Ottawa										x
Macdonald College, Ste. Anne de Bellevue, Que.							x			
Dept. of Agriculture and Rural Devel., New Brunswick							x	x		x
Nova Scotia Agricultural College, Truro, N.S.		x	x			x				
Federal Research Station, Kentville, N.S.				x				x		

Bell, D. D. 1978. The reverse cage... its place in today's egg industry. Poultry Digest 37: 166-174

Bell, D. D. and C. J. Adams. 1978. Personal communication.

Bell, D. D., M. H. Swanson, D. R. Kuney and C. J. Adams. 1979. Cage shape: its effect on layer performance. Poultry Science 58: 1035

Elmslie, L. J., R. H. Jones and D. W. Knight. 1966. A general theory describing the effects of varying flock size and stocking density on the performance of caged layers. 13th World's Poultry Congress, Kiev. 490-495

Elson, H. A. 1976. New ideas on laying cage design—the get-away cages. 5th European Poultry Conference, Malta. 1030-1041

Gilbert, A. B. 1973. The use of a calcium-restricted diet to control egg production in the domestic fowl. 4th European Poultry Conference, London. 69-76

Heath, J. L. and S. L. Owens. 1978. Effect of oiling variables on storage of shell eggs at elevated temperatures. Poultry Science. 57: 930-936

Hill, A. T. 1977. When to replace layers. Canada Agriculture, Volume 22, No. 4: 27-28. In French, page 29-30.

Hill, A. T. and J. W. Hall. 1979. Oil spraying, washing, sanitizing, storage time, strain and hen's age effects upon albumen quality, changes in storage and minimum sample sizes required for their measurement. In press.

Hughes, B. O. and A. J. Black. 1976. Battery cage shape: its effect on diurnal feeding pattern, eggshell cracking and feather pecking. Brit. Poultry Science 17: 327-336

Lee, D. J. W. and W. Bolton. 1976. Battery cage shape: The laying performance of medium and light-body weight strains of hens. Brit. Poultry Science 17: 321-326

Leeson, S., J. D. Summers and R. J. Etches. 1979. Effect of a 28-hour light: dark cycle on eggshell quality of end-of-lay birds. Poultry Science 58: 285-287

Moats, W. A. 1978. Egg washing—a review. J. of Food Protection 41: 919-925

Muir, F. V. 1976. Performance of Red x Rock sex-linked females in reverse and conventional laying cages of varying heights. Poultry Science 55: 1234-1238

Muir, F. V. and R. W. Gerry. 1976. Reverse cages and restricted feeding can be used to increase profits with brown-egg layers. Feedstuffs 48 (35): 18-19

North, Mack O. 1979. Those Leghorn strain management programs. Poultry Digest 38: 332-333

Parlour, James W. and A. M. Halter. 1970. A study of the economics of force-molting in commercial egg production. Technical Bulletin 112. Ag. Exp. Stat., Oregon State University.

Richards, S. A. 1977. The influence of loss of plumage on temperature regulation in laying hens. J. Agric. Sci. Camb. 89: 393-398

Sabrani, M. and C. G. Payne. 1978. Effect of oiling on internal quality of eggs stored at 28° and 12° C. Brit. Poultry Science 19: 567-571

Sefton, A. E. and D. C. Crober. 1976. Social and physical environmental influences on caged Single Comb White Leghorn layers. Can. J. Anim. Sci. 56: 733-738

Snetsinger, D. C., H. J. Engster and E. R. Miller. 1979. Intermittent lighting for growing pullets and laying hens. Poultry Science 58: 1109

Stewart, D. A. and R. H. Montgomery. 1977. Distributions of and relations between Haugh unit, shell thickness and other measures in a survey of eggs at a packing station. Res. Exp. Rec. Min. of Agric. Nth Ir. 25: 77-81

Swanson, M. H. and D. D. Bell. 1974. Force-molting of chickens. II. Methods. U. of California leaflet 2650

Tanabe, Hisako. 1978. Survey of methods for long-term storage of poultry eggs. 13. The effects of washing, oiling and holding on interior quality of the chicken eggs. Japan Poultry Science. 15: 55-63

Thompson, Jack and Raymond Cheng. 1978. An appraisal of potential benefits to the egg industry from selling eggs by weight. Research Bulletin 218, University of Georgia, Athens, Georgia 30602.

Wagner, R. M., R. Tuller and H. W. Rauch. 1978. Performance of laying hens in different cage types. 16th World's Poultry Congress, Rio de Janeiro. 239-242

Animal Welfare and Intensive Poultry Production

A report by J. F. Hurnik, Department of Animal and Poultry Science, University of Guelph, Guelph, Ont.

This section provides a general review of recent legislation and regulations relating to animal welfare in Great Britain and the European Economic Community, the philosophy of animal welfare and comments on some frequently heard criticisms of intensive livestock production.

The section does not contain recommendations for future research. It provides an initial review of animal welfare regulation and expresses the view that agriculturalists should actively enter the discussion concerning ethical implications of modern production methods.

Technological progress is an integral part of human evolution, being a product of human effort; it is also a powerful modifier of human behavior. It interacts with all spheres of human conduct—from fully physical to purely psychical. As we all are witnesses of accelerating scientific discoveries, we

are also witnesses of an enhanced concern for moral issues. Public awareness of the need to prevent misuse of new discoveries is increasing, and so is the desire to reevaluate and change many traditional moral standards.

Technological progress in agriculture, especially during the last few decades, has dramatically increased the productiveness of plants and animals and reduced the amount of labor required to produce food. This development has raised a broad variety of ethical questions concerning the impact of intensification on the social structure of the farming population and on the distribution of food for all humans. Regardless of such questions being raised from inside or outside agricultural circles, the fact that they are raised is a positive sign of social responsibility and ethical awareness of our society.

Environmental and managemental changes associated with the intensification of livestock husbandry prompted many individuals and groups to question whether or not the animals in modern production units are being subjected to excessive stress or physical discomfort. In my opinion, their interest reflects legitimate concern. As is the case of any new activity with social implications, in an open society the entire community has the right to determine whether any new technology is compatible with existing ethical standards. Humane concepts are a natural part of those standards.

In Great Britain, parliamentarians in the early 1960's formed an independent committee to study the implications of modern technology on animal welfare [Brambell Report (1)]. It might be assumed that the action of the parliamentarians was influenced by the public response to the book *Animal Machines* by Ruth Harrison (2). The report of the Brambell Committee contained a well-documented analysis of current conditions, resulting in a series of recommendations concerning the management of livestock. In the area of spatial restriction of farm animals, the Committee suggested that, regardless of the system of management, five basic freedoms should be respected. They are the freedom to get up, lie down, turn around, stretch their limbs, and to groom themselves.

The report represented the first serious attempt to confront the technological progress in animal production with accepted ethics. The formation of the committee was a demonstration of the accountability of society for the well-being of animals exposed to the total control of humans. It also illustrates that, in certain circumstances, society is prepared to accept other than health and economic criteria in the production of human food.

The Brambell report resulted in a legislated *Code of Recommendations for the Welfare of Livestock*, passed by the British Parliament (Agriculture Act 1968: Part I). The code refers to cattle, pigs, domestic fowl, and turkeys, and in moderate detail, specifies the requirements for adequate housing, ventilation, temperature, lighting, mechanical equipment and services, space allowances, food, water and management.

The code pays attention to management practices that cause distress. It provides guidance for handling newly born animals and exemplifies situations that increase social tensions and injury. The Act advises on dehorning of cattle, docking and identification numbering in pigs, and dubbing, beak trimming and clipping in poultry. It also sets directives regarding the timing of such treatments and the professional qualifications required to conduct them. Further regulations deal with loading, transportation and disposal of embryos and chicks.

In September, 1970, the Ministry of Agriculture, Fisheries and Food for England and Scotland published an additional document of recommendations (3). According to this publication, the key welfare issues are:

- Adequate fresh air.
- Sufficient food and of a type to keep the animal in full health and vigor.
- Ready accessibility to fresh water.
- Avoidance of mutilations of benefit only to the farmer, or for which there are reasonable alternatives.
- Freedom of movement.
- Comfort of immediate environment (e.g., freedom from draughts, and provision of a bedded lying area).
- Freedom to follow innate behavior patterns except where its denial cannot reasonably be avoided.

The publication states that the growth rate as such is not a satisfactory indicator of health and welfare because pathological conditions involving excess deposition of body fluid or fat can contribute to weight gain. Variation in protein metabolism is regarded in this reference as the best available characteristic of the presence or absence of stress.

The document also elaborates and compares ethical standards and scientific evidence regarding:

—freedom to turn around
—dim lighting
—prolonged or continuous tethering of cattle and pigs
—bedding for cattle and pigs
—slatted floors for cattle and pigs
—space standards for penned cattle
—roughage for calves
—sow stalls
—space allowance for poultry
—application of blinkers, beak trimming and dubbing

In the late 1960's and early 1970's the welfare of farm animals became a subject of international negotiations and international agreements. At that time, the Council of Europe took steps to harmonize various national laws including those related to animal welfare. The European Economic Community established directives in 1975 for the humane slaughter of animals and, in 1978, directives for the protection of animals during international transport. The European Convention for the Protection of Ani-

mals Kept for Farming Purposes (1976) established a number of principles to be considered in national legislative regulations. These relate to housing conditions, provision of food and water, freedom of movement and managemental routines which concur with the physiological and ethological needs of animals.

During the last decade, moral philosophers (4) became interested in the issue of animal welfare. Perhaps the best-known contribution in this field was made by Singer (5). His main theme concentrates on 'speciesism' defined as a 'prejudice or attitude of bias toward the interests of members of one's own species and against those of members of other species'. As a logical deduction from this definition, he is urging that we extend to other species the basic principle of equality that most of us recognize should be extended to all members of our own species. Exploitation of other species for the benefit of humans is, in his view, as morally indefensible as is the exploitation of other human beings.

Agriculturists — producers, veterinarians and animal scientists — in my opinion, must recognize the increasing public concern for the welfare of farm animals. It is rational to assume that farm animals do experience their own level of sensations — commonly understood by the term 'feelings'. Referring to poultry, all our birds possess a complex neural system able to transmit impulses from the sensory receptors to the brain and back to motor organs. The behavior of domestic birds shows that they react to rewards or punishments, and are able to neutralize adverse stimuli by escape and avoidance of fighting, according to circumstances.

Feelings as such, however, are an exclusive domain of individual experience, which we are not able to objectively measure. Obviously this is not a reason to consider animals as lacking all the sensations experienced by humans, or to ignore this matter in our approach to animals. We do not need to cross the barrier of subjectiveness as a prerequisite for an acceptance of feelings in animals. In humans we do not require such an objective proof either; we simply rely on indirect indications and on our own personal experience. It seems reasonable to extend the same principle to animals, especially to those that have substantial physiological and behavioral similarities with humans. Furthermore, sound indirect evidence can be derived from the biological function of feelings, particularly from the associative function and the evolutionary function.

The *associative function* refers to the ability of organisms to link subjective feelings with environmental or internal events (stimuli). Memorization of such relationship benefits future responses to similar or identical events. For example, the feeling of pain, associated with an event causing injury, reduces the probability of repeated injuries in the future from the same and similar events. Avoidance of painful stimuli and preference for pleasant stimuli are phenomenas which occur across individuals as well as species. It is, therefore, rational to assume that feelings provide the common motivational basis for such behavior.

The *evolutionary function* of feelings can be derived from the associative function. Organisms able to associate environmental events with feelings are more likely to adapt to their surroundings. Using the previous example, we can conclude that pain which prevents injuries, especially serious ones, increases the likelihood of survival and successful reproduction. As a result, these organisms will have greater representation in the genetic composition of the next generation. Although the effects of feelings on survival can vary and interact with many factors, we know that biological evolution tends to utilize every available characteristic according to its adaptive role. In this context we might expect that the evolution favored the incidence of feelings in many of the existing species.

Agriculturists should actively enter into the discussion concerning ethical implications of modern production methods. If they forsake their rights and responsibilities in this regard, they, along with everyone else, will have to suffer the consequence. It is perhaps realistic to expect that Canada will act similarly to Great Britain and other countries of the European Economic Community (6) and sooner or later impose certain codes or standards to protect the welfare of farm animals. Considering the potential effect on animal production, it is essential that the foundation of such standards is based on the maximum of scientific evidence and minimal subjective bias.

In the second part of this review, I would like to pay attention to some popular criticisms of intensive animal production and point out a few of the beneficial effects of modern practices on animal welfare and society.

Some critics of intensive livestock farming emphasize that the economic concerns of producers lead to disregard of some important social issues, including that of animal welfare. The producer, just as anybody else, depends on income. It is natural that the changes in technology he applies are initiated in an attempt to increase production and reduce costs. It has to be acknowledged that even under the conditions of supply controls, as we know them in Canada, this strategy has positive impact on food prices and thereby benefits society generally. Any suggestion that feed costs are the largest item among production expenses and that lessening the intensity of production would not affect or substantially alter the food prices, is mistaken. We should realize that the reason why feed is the major proportion of production costs is because confinement rearing and mechanization have largely reduced other cost components.

We have to admit that economic parameters might not in all cases be dependable indicators of high standards of animal welfare. In some situations, a cost-benefit analysis could demonstrate that lowered production performances per animal due to

density stress can be compensated for by higher numbers of animals. However, in practice, an increase in density has its own economic limits, which only a poor and uncompetitive manager would ignore.

Criticism that many modern production systems result in reduced quality of product should be supported by convincing statistical evidence. It is known that basic nutritional qualities (e.g., the percentage of protein tissue in the carcass) are consistently exposed to selection at the breeder level, as is often the palatability of the animal products. The incidence of diseases, including those which are transmissible via animal products, has also been reduced in recent years. For example, in Ontario the number of reported cases of poultry diseases has gradually declined during the past 14 years — and poultry is the most intensified of all livestock production.

Intensification has stimulated an awareness of the strict requirements for disease control and for additional research on disease prevention. Due to high economic risks, higher concentrations of animals provide incentive for efficient sanitation, which reduces the need for continuous, low levels of antibiotics in animal rations or water. However, the producer cannot directly control the composition of purchased feed. It is the responsibility of feed manufacturers to provide animal diets in which individual components are approved and within the scientifically recommended quantitative limits (7). The control of manufacturing and the distribution of growth-promoting or other biochemical agents is the responsibility of the whole society. Producers' organizations can only require that its members adhere strictly to the approved regulations for their use. In my opinion, they should do it with the utmost vigor because the reputation and economic interest of the whole industry depend on it.

Criticism that intensive livestock systems restrict the living space of animals and in some cases reduce freedom of movement is justified. However, even this may have some beneficial consequences. If one uses the example of laying hens in cages, the individual bird may benefit from continual access to water, a nutritionally well-balanced diet, reduction or elimination of social pressures on subordinate animals and better protection from temperature extremes. Obviously, birds kept under extensive conditions, in floor pens or in colony cages, usually have greater freedom of ambulation, but are also free to inflict injury or spatial and other restrictions on their peers. From an animal welfare viewpoint, it is not known how much of the potential stress of confinement can be counterbalanced by injury prevention, improved disease control and, consequently, a better state of the animal's health. Health is probably the most important prerequisite for well-being. Newly occurring health problems are predominantly caused by additional changes in the surroundings, which require difficult behavioral adjustment. This can be prevented if any new equipment or technology, prior to marketing to the producers, is tested and approved by an independent, scientifically competent institution.

So far, there are no precise, single physiological measures or guides that can comprehensibly evaluate the stress level in animal production systems. This is due to both the methodological difficulties and the very vague interpretation of term 'stress' (8). It is often necessary to assess several criteria (9) to reach a useful conclusion about what is stressful. Many compounds or metabolites relate just to single stressor agent (10) or their levels may be interdependent (11). Ethologists claim that alterations in the behavioral repertoire are still the most universal indicators of stress. This seems to be a reliable conclusion, but we have to admit that any dependable casual analysis of behavioral displays requires a very accurate definition of variation in the sensitivity of individual animals. Any other approach can lead to subjectively biased interpretations. More attention to ethology in agricultural research, and in the educational curriculum of future agrologists and veterinarians, would be very effective. Modern production managers should be very familiar with the behavioral symptoms related to various climatic, environmental, social and psychological stressors. They should be able to interpret various behavioral signals related to fear, frustration, boredom, aversion, aggression, contentment and other mental states. To maximize the production potentials of farm animals, modern producers should also know all the basic behavioral needs of animals in their various stages of life and be acquainted with the principles of conditioning, necessary for easy handling and stressless manipulation of animals.

It has been suggested that high productivity is not a reliable parameter for judging the absence of severe stress (12). This may be true in some circumstances, or where products of specific quality are required. (These products may well be justified if required for pharmaceutical or other serious purpose.) Also, the feed conversion can be improved to some degree by restricted ambulation or higher spatial density of animals. Animal production in its present form is not free of factors that could cause discomfort or stress, and to accomplish this is simply impossible. All we can and should strive for is an environment where the variety and the intensity of positive or negative stimulation corresponds with the best adaptability of animals to expected, unavoidable occurrences during their future life. For modern production systems — with stabilized managerial routines and mechanically controlled microclimate — such predictions can be made much more accurately than for the traditional systems. Recommendations for the welfare of livestock (13) are based on the evidence that protein metabolism can be regarded as a good indicator of the presence or absence of stress. Successful producers will respect this all the more as consumer preference increasingly favors protein over fat con-

tent of animal products. With few exceptions this preference relates directly to the price the producer receives for his product. Intentionally stressful surroundings are not typical of modern agricultural practices and every occurrence of such a situation calls for scrutiny and justification. For general livestock production, the hypothesis of a negative relationship between stressor and productivity of animals is more realistic than any other alternative (14). Fortunately, the wide acceptance of this relationship by producers effectively contributes to their permanent concern about the quality of the environment for farm animals.

Focussing on stress, techniques used to alter the physical appearance of farm animals, such as pig numbering, tail clipping, cutting of needle teeth in piglets, branding, dehorning, removal of distal phalanx in poults and beak trimming in chickens, cannot be ignored. Although such treatments are usually performed for the purpose of injury prevention or individual identification, they are stressful, at least at the time the operation is performed. However, successful producers know that it is in their own financial interest to conduct such treatments if needed, by experienced personnel and at the age when recovery is quickest. Nevertheless, research institutions should be stimulated to develop better alternatives.

A very important factor in intensive livestock farming is the adaptability of populations to environmental changes. All biological traits and characteristics, which are not fully genetically stabilized, show variation between individuals, and the genotype contributes to this variability. Psychophysiological traits — such as perceptual capacities, excitability, ability to learn, etc. — are no exception. Animals which are reared intensively are thus continuously selected for such an intensive environment. Behavioral adjustment of animals to intensive production systems has, therefore, adaptive value which influences the genetic composition of the next generation.

The principle of animal adaptation to an environment controlled by man is not specific to our times but has existed since early domestication. As a result, modern farm animals are very different in many characteristics from their wild ancestors or comparable wild species, regardless of whether some zoologists have doubts or claim otherwise. Several behavioral potentialities became inhibited (e.g., the capacity to fly in domestic ducks, broodiness in White Leghorn laying hens), and others became more pronounced (e.g., reproduction capacity). In the psychological sphere, many stimuli thresholds were changed — primarily those that relate to human activities. In the production sphere, current strains of chickens generate on the average 10-15 times more eggs per season than their early ancestors. Humans have helped to preserve many genetic mutations that would have little or no chance of survival (e.g., body coloring contrasting with natural surroundings). It would not be too difficult to demonstrate many other changes, including those compatible with intensive production systems. In poultry, where the intensification to date is the highest and in terms of generations, the oldest of all species, contemporary laying hens seem to be far better adapted to cage technology than those at the time when this system was introduced.

There are many other positive aspects of intensive farming important for the well-being of animals which must be considered in any fair evaluation. In this review, I would like to mention at least one which I consider as central. Agrologists and professionals associated with agriculture are far from being indifferent to the ethical aspects of contemporary animal production systems (15). A professional relationship to animals is not an obstacle to concern about animal welfare. Just the opposite, I expect a much higher probability of mistreatment by humans who instigate their 'ownership' of animals by emotional motives. (Humane societies can provide statistics of negligence due to lack of knowledge of animals, anthropomorphic interpretation of their needs, changing level of attention over time, lack of financial means or willingness to provide adequate nutrition on a continuous scale, and other errors.) It is indeed very difficult to comprehend that people who are in daily contact with animals and whose personal livelihood depends on their performance can be negligent or even cruel to animals. What kind of prospect of professional fulfillment will such people have? How would these people be able to reach or maintain economic competitiveness? What will be their social reputation, and how soon will they be subjected to existing law? I have no intention of unilaterally praising all of the present forms of animal production but I am anxious to do it justice in this regard.

The moral principle of existing agricultural practices relies on a higher priority for human welfare than for animal or plant welfare. Referring to the fundamentals of morality in the human relationship to animals, what is wrong with this principle? How can we responsibly reject this principle vis a vis consequental risks for the well-being of both symbiotic partners—humans and animals? Who decides whether a conduct is moral or otherwise? We cannot rely on sentimentalism, which is so dangerously close to egoism. I have more confidence in moral judgments based on human feelings founded on positive sympathy and appreciation of kindness, and on human rationality based on factual knowledge in its broadest sense. The two elements do not need to be in mutual opposition, but only humans are able to harmonize them.

Conclusions

Farm animals have been intentionally modified by humans into the entities that they are. Humans have, therefore, no other choice but to accept full responsibility for their welfare and future existence.

In present circumstances this can best be realized in a search for more knowledge about animals' needs, and for husbandry practices that minimize discomfort and maximize animal production.

Our technologically advanced society cannot ignore existing discrepancies in the amount and quality of food available around the globe. It is, in my opinion, a basic moral duty of animal scientists to strive for such an efficiency of animal agriculture that all human beings can afford animal products needed for their development and health. Human creativity has the potential to achieve this goal without compromise in animal welfare.

References

1. Report of the technical committee to enquire into the welfare of animals under intensive livestock husbandry systems. Chairman: Prof. F. W. Rogers Brambell, 1965.
2. Harrison, Ruth. Animal machines. Vincent Stuart Ltd., London, 1964.
3. Codes of recommendations for the welfare of livestock. MAFF, London, 1970.
4. Godlovitch, Stanley and Rosalind, and J. Harris. Animals, men and morals. Tapalinger, 1972. Regan, T., and P. Singer. Animal rights and human obligations. Prentice Hall, 1976. Clark, Stephen. The moral status of animals. Oxford, 1977.
5. Singer, P. Animal liberation: A new ethics for our treatment of animals. Random House, 1975.
6. The European convention of the protection of animals kept for farming purposes. Strasbourg, 1976.
   Policy recommendations of the Dutch National Council for Agriculture Research—The Hague, 1977. (Calling for animal welfare agreement among major livestock exporting countries.)
7. Summers, J. D., and S. Leeson. Poultry nutrition handbook. Ontario Ministry of Agriculture and Food, 1977. National Research Council nutrient requirements of domestic animals. Published by National Academy of Sciences, Washington, D.C.
8. Freeman, B. M. Stress and the domestic fowl: A physiological appraisal. World's Poultry Science Journal 27: 263-275.
9. Siegel, H. S. Adrenals, stress and the environment. World's Poultry Science Jounral, 27: 327-349, 1971.
10. Stefanovic, M. P., H. S. Bayley and S. J. Slinger. Effect of stress on swine, heat and cold exposure and starvation on vanilmandelic acid output in the urine, J. Anim. Sci. 30: 378-381, 1970.
11. Di Giusto, E. L., K. Cairncross, and M. G. King. Hormonal influences on fear-motivated responses. Psychol. Bull. 75: 432-444.
12. Thorpe, W. Welfare of Domestic animals. Nature. 224: 18-20, 1969.
13. Codes of recommendations for the welfare of livestock. MAFF, London, 1970.
14. Ringer, R. K. Adaptation of poultry to confinement rearing systems. Symposium—Sound animal care a prerequisite to productive husbandry, Penn. State University, 1970.
15. Loew, F. M. The veterinarian and intensive livestock production—humane considerations. Can. Vet. J. 27: 29-233, 1971.

Kilgour, R. Minimizing stress on animals during handling. Proc. 1st Word Congress on Ethology Applied to Zootechnics, Madrid, pp. 303-322, 1978.

Brantas, G. C. Ethological evaluation of cage and sloped wire floor management for hens. Proc. 1st World Congress on Ethology Applied to Zootechnics, Madrid. pp. 251-256, 1978.

Egg and Layer Marketing

A report by C. J. Randall and A. B. Allen, Food Production and Inspection Branch, Agriculture Canada, Ottawa.

Product Wholesomeness

Nutrition/Composition

An egg is a perishable food product enclosed in an inedible package: the shell (11%) within which are the white (58%) and the yolk (31%). The egg has a high nutritional value, containing 6.6 grams of high-quality protein composed of all the essential amino acids necessary for man, 6.0 grams of fat and 0.6 grams of carbohydrate. It contains all the essential vitamins, except vitamin C, and has many of the minerals.

Much of the chemical and nutritional information on eggs in textbooks was derived from data obtained before 1950. Because of changes in breeds, management, feeds, etc., there is a necessity for constant revision of chemical and nutrient composition tables. Recently, the United States Department of Agriculture, as well as Dr. Cotterill of the University of Missouri, published revised tables of the nutrient composition of eggs which give data on amino acids, minerals, vitamins and fatty acids. Although it can generally be assumed that American and Canadian eggs are comparable, a small pilot study needs to be initiated to substantiate the values for some key elements before we accept the values in these tables as absolutes for eggs produced under Canadian conditions.

The chemical composition of Canadian eggs, including the solids content, needs to be evaluated.

Are the values currently used in our grade standards realistic under today's production systems?

One element in the egg that has caused considerable controversy in medical circles is the high cholesterol level in the yolk. It is generally thought that atherosclerotic heart disease is positively correlated with blood cholesterol level. This led, some years ago, to the erroneous conclusion that eating cholesterol would lead to increased heart disease. This caused many members of the medical profession and nutritionists to conclude that egg consumption should be limited to two or three eggs per week. Recently, various reports have shown that eating one or two whole eggs per day for a period of up to 12 weeks has little effect on blood cholesterol levels and suggests that the indiscriminate exclusion of eggs from the diet may prove to be a useless measure in lowering blood cholesterol and triglycerides. Presently, the American Egg Board is providing some $500 000 for seven or eight projects which are being conducted to study the effects of eggs in the human diet, with specific reference to the cholesterol issue.

There has been some research on the modification of the fatty acid composition of the egg, but the little effect such eggs have on changing serum cholesterol levels and with the above-mentioned results, this type of research would appear to have little future.

The best approach for Canada would be for some agency such as CEMA, which has put out information sheets on cholesterol research, to maintain a watching brief on this subject and have pertinent information distributed to food editors, public health personnel, the medical profession, and others.

Microbiology/Sanitation

The egg is sometimes referred to as the nearly perfect package and many in the industry have tended to forget — or perhaps never realized — that they are handling a very fragile and perishable food product. The cuticle, shell, shell membrane and the albumen function to protect the egg from bacterial invasion and contamination. Since the egg is so well protected by nature, there is a tendency to take the sanitary aspects for granted. However, the occasional report of 'rots' in stored eggs make it obvious that the egg is not infallible and that good sanitary practices need to be followed, both at the producer and the grading station level. The consumer handles raw eggs routinely in the kitchen and is entitled to a clean, sanitary food product.

The producers must continuously be aware of the fact that they are producing a perishable food product and should constantly keep this in mind at all stages in their handling of eggs. Eggs for the most part are clean when laid, but the shell of an apparently clean egg will have an average microbial count of 100 000. What kind of counts are there on those obviously dirty eggs that one sees routinely entering a grading station? Dust, soil and feces are the main sources of contamination, and one wonders why our producers will allow eggs to lie in cages with caked-on dust and manure. The placing of eggs in wet and dirty Keyes trays adds to the problem of high microbial counts on eggs. To keep the counts low, the producers must be producing clean eggs which have been gathered under clean conditions and placed in refrigerated storage soon after lay.

There has to be something wrong with a system that permits 'dirty' eggs to be cleaned and sold as a food item, but a similar type of 'dirty' egg from a breeding operation is not good enough to be placed in a hatchery incubator. No amount of research will justify placing dirty eggs into the system and expecting them to be a wholesome food product. This type of practice reflects on the entire egg-producing industry, and education rather than research is needed to curtail the marketing of such eggs.

At the grading station, eggs are again subjected to practices that can contribute to microbial contamination, the most important being the wet washing of eggs. Besides improving the appearance of the eggs and thereby consumer acceptance, washing can be effective in removing surface dirt and 80-90% of the bacterial load. However, washing removes the cuticle of the shell, increasing the possibility of bacterial penetration of the shells. The literature contains numerous references to the increased spoilage ('rots') of washed eggs versus unwashed eggs when stored for extensive periods. Such reports strongly suggest that bacteria can penetrate the eggshell during washing and multiply during subsequent storage. Some researchers are of the opinion that penetration of the eggs by bacteria during the washing cycle is a factor contributing to reduced quality of eggs.

Because eggs are a food product, one would think that the egg-grading station should be considered as a food-handling (processing) plant. Insanitary conditions — such as dirty floors, and improperly cleaned machinery and belts — at many of the grading stations makes one aware that such is the exception rather than the rule, and makes one wonder about the philosophy of the egg industry. Is this industry concerned about the future of the egg as a food product?

The following data will help to illustrate this point. In a study in Ontario, only 7% of wash-water samples had bacterial counts of less than 10 000 per ml, 68% had more than 10 million per ml, with some counts being even greater than a billion. Counts of 1 million per ml and higher were even found at start-up, indicating that the machines were never properly cleaned after the previous day's operation. How can the industry expect to supply clean, wholesome eggs or reduce microbial counts on the eggs if they are subjected to these conditions. One promising aspect of this study is that an awareness of the problem occasionally results in

substantial improvements in wash-water microbial counts which could mean that a better-quality product is reaching the consumer.

Beyond the washer, the grading, sorting and packaging processes all contribute to microbial counts and probably more so, if the eggs have not been dried properly. In our study using averages, the counts were 5.21×10^4 per visibly clean egg; 1.11×10^5 per egg at the exit from the washer, and 1.86×10^5 on the packaged egg. These results clearly demonstrate that mocroorganisms can be picked up after the washer, and again point out the lack of sanitary practices. Major improvements in the sanitation practices of egg-grading stations are required.

The industry is well aware that today's production and handling systems result in numerous cracked eggs. Once the shell is cracked, microorganisms from any number of sources, including the wash water, can easily enter the egg. Cracked eggs do harbor a greater number of microorganisms, as the following results from our studies demonstrate: sound eggs, 1.8×10^4 per egg; slightly cracked eggs, 1.3×10^6; badly cracked eggs, 1.1×10^7. Such results also point out the need for the grading station to have an adequate sanitation program if such eggs are to be considered a wholesome food product, rather than a potentially harmful product. The time has arrived when the industry must realize that the egg is a food commodity and that the grading station must operate as a food-processing plant. In the area of microbiology/sanitation at the egg-grading station level, several projects need to be undertaken:

- An efficient sanitation program needs to be devised for egg-grading stations.
- Because of known problems with the washing of eggs, there should be research on alternative means of cleaning eggs, be it a more-efficient washing system or a totally different system which eliminates the need for the wet washing of eggs.
- A feasibility study on the effect of bacterial penetration of albumen on egg quality needs to be undertaken.

Egg Quality

Measurement

Egg quality can be viewed in terms of (a) the firmness of the albumen, (b) a strong and reasonably smooth, clean and uncracked shell and, (c) the absence of meat and blood spots. The measurement of quality of eggs from 'nest-run' production was initially made by:

—visual examination to determine the presence of a smooth, well-shaped and clean shell

—'belling' the eggs—gently touching the eggs together to determine if the shells are cracked

—rotating an egg in front of a light to determine firmness of albumen, presence of meat or blood spots, etc.

The third method of categorizing eggs was accomplished by rotating the eggs in front of a light by hand, or with a single-line grading machine where the eggs were rolled over a light beam.

Today, mechanized grading has developed to the stage where the machines wash, grade, size and carton eggs at a rate of over 50 000 per hour. With this type of grading, emphasis has switched from the individual egg to the lot of eggs being graded. Sometimes referred to as flock grading, this system works well for those lots that are of good quality and that do not require much sorting. The scanners on these large mass-candling machines have limited time to look at the eggs to determine if the shell is misshapen or rough, clean and unbroken, or if the interior is free of meat and blood spots. The scanner can experience difficulty in selecting eggs with thin albumens by this method. A flock that is well managed will produce eggs of sufficient quality so that the scanner can successfully remove those showing a yolk with a distinct outline and which rotates easily, indicating a thin albumen. However, if the management is poor (diseased or old birds, or lack of cooling facilities) eggs of low interior and shell quality will be produced that are virtually impossible to scan successfully. These eggs make up a small proportion of the total eggs marketed. It would appear that as long as there are no real incentives to produce good-quality eggs, some producers will continue these kinds of practices.

Consideration should be given to a different type of assessment of this interior quality, either in conjunction with present grading machines or perhaps prior to scanning. A possible consideration is to assess the interior quality of the eggs prior to scanning on a flock basis. For example, those flocks producing eggs of poor interior quality might be separated and dealt with in a manner other than by the large mass-candling machines. One manner of evaluating the thickness of the albumen on a flock basis would be by use of Haugh unit measurements. Briefly, this is a mechanical measurement of the height of the albumen of a broken-out egg. Having established a poor-quality rating for the flock, the eggs would then be directed to egg-processing stations for breaking.

Consideration could be given to a marketing system that might remove these low-quality eggs from the table market and replace them with a better-quality egg. Often medium-sized eggs, usually of good quality, are declared surplus by the industry and directed to breaking plants. Good-quality eggs need to be directed to the table market and eggs of poor quality to the processing industry.

Retention of Interior Quality

To maintain consumer confidence, eggs must maintain reasonable quality through the marketing system. Some of the concerns in retaining this quality are summarized adequately in studies conducted by A.T. Hill of the Agassiz Research Station. Figure 2 shows the effect of oiling versus non-oiling on quality retention of eggs stored up to 26 days. Most eggs marketed in Canada are not oiled. As shown by the figure, the greatest decline in the Haugh units values occur during the first few days after lay. If eggs are not stored properly at this time, the decline in quality will be much sharper and greater than that shown.

Figure 3 shows the influence of age of flocks on the retention of interior egg quality. The retention of quality of eggs from flocks that are nearing the end of their normal laying cycle (especially if the eggs are not refrigerated) is virtually impossible when we consider the present marketing patterns. Even though these eggs may be of passable quality when laid, they will not retain that quality unless they are properly cooled and oiled, and marketed quickly. Selection pressure may be applied at the grading station; however, those meeting minimum quality at that time will deteriorate within a few days.

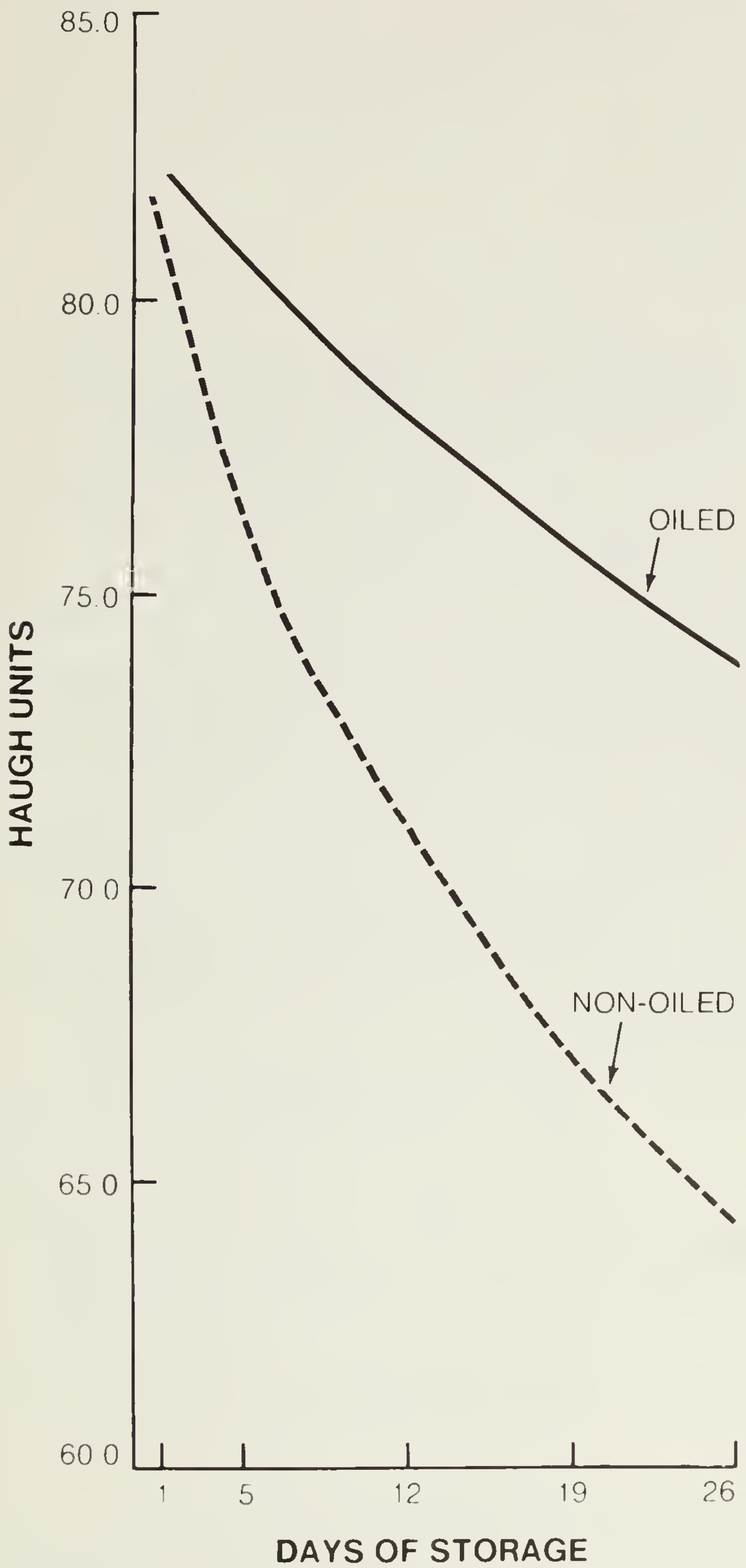

FIGURE 2. Oiling effects on Haugh units of Albumen in eggs stored 1-26 days

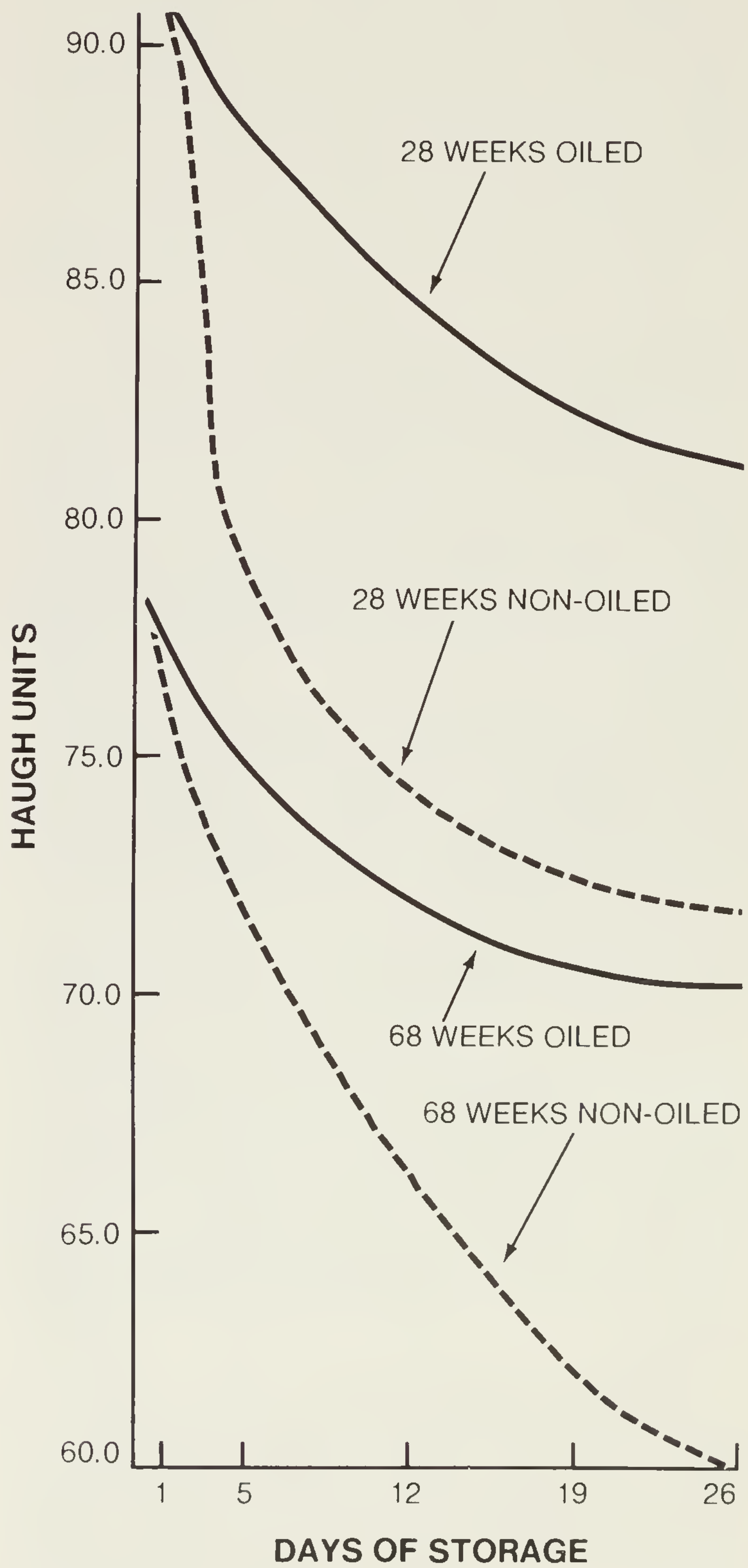

FIGURE 3. Differences in Haugh units between fresh and stored eggs from 28- and 68- week-old layers

Shell Quality

Commercially, the evaluation of shell quality at egg-grading stations is subjective, being done visually by the scanner. A judgment is made on the shape, smoothness, and whether or not the egg is cracked. After this grading point, further cracks may and do occur. It is estimated that eggs will obtain an additional 1% cracks each time they are handled throughout the system, but this varies from operation to operation. Where eggs with poorer shells are involved, this means a substantially higher number of cracks at retail level, particularly where larger sizes of eggs are involved.

The production of a sound shell is mandatory for the system, which includes collection, shipment to grading station, handling at the grading station (including loading the machines, washing, scanning, drying, sizing, packaging and storing), transportation to the retail store (via wholesaler in many situations), handling in the cooler and display counters at retail level and finally, handling by the consumer.

Much work has been done to date on the testing of cartons of different types of construction and has resulted in some good designs which seem to protect the egg satisfactorily. There also is a testing program for larger containers of eggs.

The perfect package for shell eggs has not yet been developed and breakage continues to occur as eggs are being handled in cartons. The basic design for egg cartons has not changed for some time. Cartons have been designed with larger dimensions for use when packing jumbo-sized eggs; however, this carton is not used extensively by the industry.

Under present Canada Egg Grade Standards, Extra Large-sized eggs (over 2½ oz) are permitted to be packaged with the Large-sized eggs (over 2 oz). This represents a difference in the sizes of eggs in a carton. This unevenness could easily result in the larger eggs being cracked when transported.

Along with the protective aspects of the carton, the insulating properties must be taken into consideration. Assuming that the egg is cooled before packing, the carton would have the advantage of assisting in maintaining the cool temperature. Conversely, if the eggs are warm preceding the scanning and washing procedures and possibly a little wet, the carton will aid in containing the warmth in the eggs. This impedes proper cooling of the eggs under good holding conditions. The presence of moisture on the eggs contributes to bacteria growth.

Regardless of the type of carton or bulk container used, the amount of breakage that occurs is directly related to the condition of the shell. A strong, soundly constructed and normal-shaped eggshell will withstand the abuse of our present marketing systems. Not only do properly constructed shells lower the amount of breakage of eggs, but this type of shell will also aid in the retention of interior quality throughout the system. Eggs with thinner, more-porous shells generally have a much shorter shelf life.

Yolk Color

Feed has a direct influence on yolk color. Recent surveys conducted by Agriculture Canada show a wide variation in color ranges between Eastern and Western Canada. Shipments of eggs from Western Canada to Quebec and Ontario have always resulted in consumer complaints regarding the 'pale' or light color of the yolks.

Consideration might be given to establishing a color range that would be acceptable in all areas. This range, perhaps a 3-6 reading on the Hoffman LaRoche color fan, would be high enough to satisfy the Eastern Canadian market and low enough to be acceptable by the consumers in Western Canada. Economic studies would have to be carried out to establish what the added cost would be to western producers.

Marketing Eggs by Weight

Interest has been shown from time to time in marketing eggs by weight. Presently eggs are required to be sorted into various size ranges:

Extra Large—over 2½ oz Large—over 2 oz
Medium—1¾ to 2 oz Small—1½ to 1¾ oz
Pee Wee—under 1½ oz

This system of size ranges has been used in Canada for many years.

Selling eggs on a weight basis would mean that consumers could buy eggs in cartons similar to the ones used now, but the cartons would be marked with the price per pound and the weight of the contents.

Studies have been conducted on this subject by various groups. A more recent study, *An Appraisal of Potential Benefits to the Egg Industry from Selling Eggs by Weight*, was published by the University of Georgia. Some of the findings of the study were:

- Consumers would be able to compare prices among different sizes and with other food products if eggs were marked with a weight. Eggs compare favorably with other products when 'per pound of protein' is considered.
- Producers would have a precise measurement of flock performance, important for decision-making in such matters as feed formulation, breed selection, and flock management practices.
- There would be added costs in the weighing of the eggs at each level of transaction: from procuder to grading station, grading station to wholesaler or retailer, and retailer to consumer.

While many other advantages and disadvantages exist, it would require a tremendous amount of market research and study before any conclusions could be reached on the real effect on the industry of selling eggs by weight.

Summary

The majority of factors affecting egg quality are known, be it at the producer, egg-grading station, or retail level. It is now imperative that the Canadian egg industry put these into practice so that the consumer can purchase a high-quality food commodity.

References

Cotterill, O. J., W. W. Marion, and E. C. Naber. 1977. A nutrient re-evaluation of shell eggs. Poultry Sci. 56:1927

Cotterill, O. J. and J. L. Glauert. 1979. Nutrient values for shell, liquid/frozen and dehydrated eggs derived by linear regression analysis and conversion factors. Poultry Sci. 58:131

Canadian Egg Marketing Agency. 1978. Information sheets: New directions—cholesterol research; the cholesterol theory; effect of eggs on serum cholesterol levels.

Elliott, J. A., D. J. Randall and K. Ewan. 1979. Egg washing, grading and packaging: effects on the microbial load of eggs. (Paper in preparation.)

Moats, W. A. 1978. Egg washing—A review. J. Food Protection, 41:919.

Moats, W. A. 1978. The effect of washing eggs under commercial conditions on bacterial load on eggshells. Presented at Poultry Science Association meeting, July 1978.

Posati, L. P. and M. L. Orr. 1976. Composition of foods—dairy and egg products—raw, processed, prepared. USDA Handbook No. 8—1, U.S. Government Printing Office, Washington, D.C.

Stadelman, W. J. and O. J. Cotterill. 1977. Egg science and technology. Second edition, Avi Publishing Company Inc., Westport, Connecticut.

Engineering and Housing Equipment and Design

A report by N.A. Bird, Ontario Ministry of Agriculture and Food, Stratford, Ont.

The purpose of this report is to identify the research priorities in agricultural engineering for the Canadian egg-production industry. To obtain efficient production, it is necessary to know how and where agricultural engineering research applies to egg-production farms. For example, how it fits in with research in other fields of egg production, such as genetics; where it could apply to help to solve an immediate problem, such as suitable manure storages, and how it could help to ensure the future of the industry through energy conservation research.

The information in this section is based on the point of view of an extension agricultural engineer—not that of a research scientist. The examples of research work that are used are for illustration only and do not cover the whole field.

In addition to contribution to an understanding of agricultural engineering research, this section also contains suggestions as to the problems to be tackled by research. Included are priorities for producers to examine, so that they and the researchers have a common approach in solving these problems. There may be areas where the equipment industry and government research should work more closely together and areas where producer organizations could help to obtain results, for example, how well suited to Canadian farms are the different laying cage systems. This kind of test is not easily performed in the laboratory.

Engineering Research in the Egg Industry

Buildings

Poultry buildings are inexpensive and durable. They are designed for efficient construction, using high-quality materials. The large quantities of timber, plywood, galvanized steel, concrete and insulation used in the construction of the buildings provide an important market for material manufacturers, and some manufacturers have contributed to research on livestock and poultry structures.

Poultry buildings in Canada are generally different from those in the U.S. In Canada, they are built for higher snow loads and lower temperatures. Generally, Canadian poultry houses are long, and this presents a special design and construction problem with respect to wind bracing.

Structural designs and efficient structural systems are available to Canadian poultry producers through the Canada Plan Service. These designs are prepared by the Engineering and Statistical Research Institute, Agriculture Canada. They meet the farm building standards of the National Building Code and are kept up-to-date through a continuous program of testing and the incorporation of new designs.

The poultry housing plans of the Canada Plan Service are not extensively used by the industry, but through educational programs, the important structural features are gradually adopted. On this point the producer has stated his priorities: he is not as interested in building codes as is the structures researcher.

Designers of poultry buildings in Canada depend mainly on Canadian building research which is closely related to Canadian building codes, Canadian construction materials, and methods. The resulting designs are structurally adequate and efficient.

The farm building construction industry develops innovative designs during periods of active building. This is the case in the swine industry, to some extent in the broiler industry, but less so in the egg industry. Innovations from these other areas may be adapted for egg-production buildings.

Lighting, Heating and Ventilation

Lighting, heating and ventilation are part of the buildings and equipment research program, but they are also very much in the animal scientist's field of study. Beside feed, they represent energy consumption and are the focus of energy-conservation studies.

A large amount of research has been conducted and is continuing to be done on ventilation. The results of research on the perimeter air intake slot, for example, Turner and Davis (1) and the 'hydro box' developed by Milne *et al.* (2), can be found in many Canadian poultry houses today. Canadian exhaust-fan manufacturers make and sell the fan sizes to suit ventilation system designs based on agricultural engineering research. Companies making ventilation equipment have researched and developed complete ventilation systems for the poultry and swine industry.

Lighting and heating research has not involved the agricultural engineer as much as the poultry scientist, the breeding companies and the equipment manufacturers.

The Canadian egg industry will benefit from greater cooperation in research. This cooperation may come as a result of further emphasis on energy conservation and alternate energy research.

Feed Processing and Handling

Basic information in this area changes little. The equipment used to move grains and feed, grind, proportion and mix ingredients follows laws that can be used to design feed-processing systems. Therefore, much of the past research in this area has been to complete the tables of conveyor and mill power requirements, angles of repose of materials, accuracy of proportioners, uniformity of mixers, and the drying and storing of grains. This type of research carried out at agricultural engineering departments across Canada was closely associated with the Agricultural Materials Handling Manual (3) published in the early 1960's and which is being revised.

With interest in energy conservation and in alternate energy sources, new research is being done on grain drying. This is of special interest to egg producers who also produce their grain for feed.

At the other end of the feed-handling scale is the mechanical poultry feeder. This too is under energy-conservation scrutiny to reduce costs by preventing waste of feeds and electric power. Research into feeder design has mainly been done by the equipment manufacturer and the result of this research is the feeder itself. Comparative results come from the producer's operation. Research to produce comparative results cannot easily be done by an agricultural engineering department. Research has, however, been done on mechanical hog feeders, and probably is done on large, integrated poultry farms where feeders as well as total systems can be compared. Canada has egg producers with small production capacity. Perhaps these producers should have the benefit of some type of comparative research. On the other hand, perhaps the strong competition between poultry equipment companies eliminates the poor designs faster than could comparative tests.

Cages

Poultry science research departments have studied cage shape and size in relation to strain of bird, feeding space, waterer space, feed consumption, mortality, eggs per hen and other criteria. Manufacturers of feeders and waterers have done their own research to design the best feeding system and the best waterer, and to locate the waterer in the cage at the most suitable position.

Cage manufacturers have designed complete cage systems based on their research and on the demands of the producer. They have also built cage systems to producers' designs. A recent example that illustrates the development process in cage design is the 'reverse' cage. Research by Bell (4) and Martin (5) demonstrated the improvements in feed conversion, eggs per hen and mortality through the use of a cage that provided more feeding space and a lined-up hen arrangement. A number of manufacturers developed a complete cage system based on this concept. Producers bought it, partly because manufacturers introduced them to the research results on which it was based, and also because it simplified manure removal, reduced manure related equipment deterioration, reduced cracks, and increased house capacity. Canadian research by Hill and Hunt (6) produced some contrasting results to those of Bell (4) and Martin (5). Therefore, we do not know whether the various 'reverse cage systems' have the potential for improved performance based on the original research conducted. Thus, the real comparison is between other cage systems rather than other cage shapes. Where possible, producers will select the most profitable bird density based on farm records

and will never know whether another system with another cage shape, another feeder and waterer, another bird density, and another price would have been more profitable under their management.

Complete Systems

The 'reverse cage' is an example of a cage shape incorporated into a cage system. It is still not complete. To this we add the lighting and ventilation, the manure-handling system and other features.

Equipment manufacturers have planned complete systems. So have building contractors, producers, extension and research agricultural engineers, poultry management consultants and poultry breeding companies.

Designing a complete system is more an art of putting the pieces together. What is needed is the research and development that goes into each piece to include the requirement and the limitation of the system. Ventilation may not only be required for the birds but also for the manure. A choice of lighting equipment may interfere with ventilation. A choice of heating systems may depend on the brooding cage design.

Manure Handling

Considerable agricultural engineering research has been done on manure handling. Manure, especially for the egg industry, is an important resource. It is a by-product of high economic value. Its importance has been shown by the research that has been done in developing dryers, for example, Meiering *et al.* (7). Although considerable research has been directed to odor control through aeration, this is an energy-wasting process and should have lower priority than research into methods of stabilizing manure and keeping the nutrients for fertilizer or other uses. Several such systems have been developed through research. Bressler and Bergman (8) developed the stirring scraper system to produce air-dried manure from cage and wire floor houses. Hall *et al.* (9) developed an air drying system assisted by ventilation air and solar heat. The 'high-rise' system has been studied and further developed by many researchers in government and industry. It is an example of a complete system in which manure handling has not been forgotten. It is especially suited to Canadian conditions because it provides long-term storage for manure to be used in crop production. The system is not gaining acceptance. For one thing, Canadian producers are reequipping existing barns rather than building new ones. But the real reasons are the lack of adequate performance from high-rise houses in Canada, and wet manure. Since the high-rise house has such a good manure system, these two problems should be solved.

For brooding barns and for conventional cage barns, Canadian producers generally handle the manure as a slurry, storing it in covered or open concrete tanks. The system works, but there are problems to be solved. Agitation and pumping is one problem, odor is another.

Disposal of Dead Birds

This is a problem that doesn't have economic importance, and therefore receives very little attention. Equipment manufacturers have developed incinerators that meet various U.S. and Canadian standards for performance. The most difficult standard to meet involves adequate temperature and time to kill pathogens in the flue gases. This problem is generally being ignored. It would be good public relations to solve this problem. It involves the poultry and swine industries.

Some producers have cold storage for dead birds so that they can be picked up by disposal companies. Very little has been done to get this system working.

As a summary to this review of how agricultural engineering research fits into the egg industry, Table 17 shows the common flow of problem-solving requests. Notice how the different disciplines overlap and how people from various types of research departments might be working independently on the same problems, depending on the direction that the request might take. This is typical of agricultural engineering research and perhaps one of the reasons behind Agriculture Canada's Agricultural Engineering Research and Development Program (10). This is a program of contract research projects with individuals, companies, and government research departments. Some contracts have been concerned with the research needs of the egg industry.

Engineering Research Needs

Buildings

It is thought that we should continue to develop new poultry housing designs. Although there are a small number of new buildings being constructed, we do not want to fall behind in the application of new construction methods and new materials. With materials, for example, there are some problems that are still to be solved. Ways of using foam plastic insulations so that they are fire resistant, and ways of preventing rodent damage to insulated walls are two examples. New construction methods may come from many sources — contractors, producers, research stations and companies. These are passed along to agricultural engineering researchers, for example, through the Canada Plan Service Poultry Committee to the Engineering and Statistical Research Institute, Agriculture Canada. Here they

TABLE 17. How Agricultural Engineering Problems are Handled in the Canadian Egg Industry

Problem area	Problem identified by	Problem directed to	Source of research information used in solution
Buildings	Producer Building contractor Building inspector Agricultural engineer	Agricultural engineer Materials supplier	ESRI* (Canada Plan Service) Materials manufacturer Engineering department
Lighting, Heating, Ventilation	Producer Poultry management Fieldman Veterinarian Agricultural engineer	Electrical utility Agricultural engineer Hatchery Equipment supplier	Electrical utility ESRI (Canada Plan Service) Feed company Breeding company Equipment manufacturer Animal science, engineering depts.
Feed processing and handling	Producer	Equipment supplier Agricultural engineer	Electrical utility Equipment manufacturer ESRI (Agr. Materials Handling Manual and Canada Plan Service) Engineering dept.
Cage systems	Producer Management Fieldman	Equipment supplier	Equipment manufacturer Breeding company
Total system design	Producer Contractor	Agricultural engineer Hatchery Equipment supplier	ESRI (Canada Plan Service) Equipment manufacturer Breeding company
Manure handling and dead bird disposal	Producer Environment ministry	Agricultural engineer Equipment supplier	ESRI (Canada Plan Service) Animal science, crops, engineering depts. Equipment manufacturer

* Engineering and Statistical Research Institute, Research Branch, Agriculture Canada. Some provinces depend more on provincial plan services.

can be incorporated into building plans for everyone's use. Although we are only thinking of the structure at this point, the same lines of communication apply to ventilation and heating systems, manure systems and the complete system design.

Lighting, Heating and Ventilation

In the areas of lighting, heating and ventilation, consideration is given to both short-term and medium- to long-term energy conservation. In the short-term, we would like to see a study on the various ways of reducing energy in existing housing. This type of study has been done for broiler production by Rothwell (11) and Cooke (12). On a medium- to long-term basis, research should continue on solar energy and heat exchangers for ventilation air. There are many projects being carried out on solar energy. Winfield (13) is doing research on a method of storing solar heat in a concrete-block wall for ventilation air. This approach has promise for poultry barns. Ontario Hydro has developed a ventilation heat exchanger system for a poultry farm. Larkin *et al.* (14) have experimented with a thermal siphon heat exchanger for layer housing. There are many possible projects in this area. The ventilation heat loss from layer barns, if returned to the incoming air, would allow increased ventilation rates, increased house temperatures and improved manure drying. For brooding and breeder flock barns, reclaiming ventilation heat would also reduce the consumption of energy for supplementary heat.

Improving the energy efficiency of exhaust fans and of ventilation systems is important. Canadian egg producers would benefit if Canadian fan manufacturers were supported in improving the efficiency of their fans. This type of project should also include a fan performance rating, so that producers would know the fan performance. This work would benefit all poultry and swine, but layer housing, in which the most air is moved per animal unit, would benefit most.

Feed Processing and Handling

No specific recommendation is made in this area. Perhaps research needs will show up more clearly from a review of the needs of research on nutrition. Work is in progress to revise the agricultural materials handling manual. This will be a useful handbook to egg producers, both directly and indirectly through extension and agribusiness.

Cages

On a short-term basis, we do not believe that there would be any benefit in initiating research into new cage designs. On a long-term basis, we should be increasing our knowledge of cage designs as it relates to bird behavior and welfare. Studies in this area are being carried out at the University of Guelph, and it is an area where agricultural engineers and poultry scientists can work together.

Complete Systems

We do not see this as an area for research. However, the area of complete systems is a necessary and important part of the work of the Canada Plan Service in preparing poultry-housing plans. There needs to be more information available—through more research and better communications—on the components of systems so that the Canada Plan Service, equipment companies, extension people, contractors and producers can put together better-planned complete systems.

Manure Handling

We would like to see the problem of wet manure in high-rise houses receive more attention by researchers. It may require a study of management practices, waterers, overflow collecting systems, salt content of feed, ventilation, air circulation, added solar heat, and strain of bird. The support of producers is needed. There is no point in concentrating on the high-rise house if producers are not going to build them. Uncertainties about the performance and economics of high-rise houses should be examined first.

For the large number of conventional cage houses that do not have adequate manure storage to allow good manure utilization, we should determine which pumping system and tank sizes are best for liquid manure.

For conventional cage houses that are too close to neighboring dwellings to permit the use of a liquid manure system, we should apply the Bressler stirring scraper system, then determine what conveying equipment is needed and develop a workable, roofed dry storage for the air-dried manure to be stored for crop utilization. The air-dried manure approach offers more flexibility in the sale of manure to crop-production farms. It is much less odorous and there is much less weight, but it cannot be pumped and it must be kept dry.

Disposal of Dead Birds

Manufacturers should be encouraged to develop incinerators that meet the local codes throughout Canada.

References

1. Turner, C. N. and H. R. Davis. A ventilating system for high density housing of poultry. ASAE Paper No. 67-942. St. Joseph, Michigan. 1969.
2. Milne, W. R. and R. G. Winfield. Ventilation for poultry and livestock. Ontario Hydro, 700 University Ave., Toronto, Ont. 1973.
3. Agricultural Materials Handling Manual, Agriculture Canada, Ottawa. 1962.
4. Bell, D. New cage designs offer higher income possibilities. Poultry Tribune 83(5): 14, 16. 1977.
5. Martin, G. A. Shallow cage design improves profit. Poultry Tribune 83(3): 32. 1977.
6. Hill, A. T. and J. R. Hunt. Layer cage depth effects on nervousness, feathering, shell breakage, performance and net egg returns. Poultry Science 57: 1204-1216. 1978.
7. Meiering, A. G., F. B. Hesse, and J. Pos. Odorless drying of food production and processing wastes. CSAE Paper No. 73-210. Presented at CSAE Conference. Victoria, B.C. 1973.
8. Bressler, G. O. and E. L. Bergman. Solving the poultry manure problem economically through dehydration. Proceedings-International Symposium of Livestock Wastes, ASAE, St. Joseph, Michigan.
9. Hall, F., M. Esmay, C. Sheppard and C. Flegal. Summer utilization of solar energy for drying poultry excreta. ASAE Paper No. 77-4536, St. Joseph, Michigan. 1977.
10. Agriculture Canada's Energy Research and Development Program. Report I-107, Engineering and Statistical Research Institute, Research Branch, Agriculture Canada, Ottawa.
11. Rothwell, T. (Martin Feeds Ltd., Elmira). Save energy—save dollars. Paper presented at the 1979 Poultry Industry Conference and Exhibition, London, Ont. 1979.
12. Cooke, H. W. Energy conservation—broiler chicken lighting. Paper No. 77-405 presented at the CSAE Annual Meeting, Guelph, Ont. August 1977.
13. Winfield, R. G. Performance of solar collector storage walls in farrowing buildings (a progress report). Proceedings—Ontario Pork Congress, Stratford, Ont. 1979.
14. Larkin, B.S., J. E. Turnbull and R. S. Gowe. A thermosiphon heat exchanger for use in animal shelters. Paper No. 77-210 presented at the CSAE Annual Meeting, Laval University, Ste. Foy, Que. 1974.

SUMMARY OF PROCEEDINGS

At the conference in Ottawa, attention was directed primarily to research and extension requirements related to the production, handling and management of eggs at the farm level, including the breeding and raising of laying hens. The meeting did not deal with egg distribution and processing beyond the farm gate, nor with market development and marketing policy *per se*.

Listing of Research Priorities

A result of the deliberations was the listing and ranking of research priorities as summarized in Table 18. The list, which also includes categorization of priorities in terms of time, is divided into nine groups, with the priority ranking within, and not between, the groups. It was concluded at the conference that to attempt an overall listing of priorities for all groups was beyond the capacity of the participants in the time available. In practice, the setting of research priorities is influenced by many factors, including the availability of the necessary expertise and research facilities at a particular time. However, it was possible to identify the major concerns of the conference participants that have a bearing on research priorities.

It was strongly emphasized that Canada must maintain poultry research centers—and the reseach programs associated with them—on a basis that will ensure that the industry does not fall behind in meeting short- and long-term requirements for improved productivity and economic viability. An important component of planning is to give research support at the university level in order to maintain a sound system of post-graduate training and ensure the future availability of trained personnel. These concepts are described in this review in the section on egg production and marketing research.

Research on egg production and marketing needs to be coordinated and interdisciplinary. Participants at the conference emphasized the necessity of a balanced program of basic and applied research, in both the long- and short-term. It is necessary to maintain this balance in allocating priorities. A team approach, in which many research disciplines contribute, yields the best results.

Egg-production research was considered under the following headings:

Animal welfare and itensive poultry production

Egg and layer marketing

Engineering and housing equipment and design

Genetics and breeding

Layer flock health

Metabolism and endocrinology

Nutrition: energy and protein

Nutrition: minerals, vitamins and antibiotics

Pullet and layer flock management

In reviewing the work of the groups studying these research areas, the meeting placed considerable emphasis on the need to conduct research in the field, in an environment approximating the conditions of the normal laying flock. This is likely to be costly and may require the cooperation of the egg producers. Emphasis was also placed on the need for research findings that take into account the climate of Canada.

A number of groups gave fairly high priority to improvement of shell quality. This is a problem that requires an interdisciplinary approach, involving physiology, engineering, breeding and other sciences. It was recognized that more was known about the means of ensuring better eggshell quality and less breakage through nutrition and management than was being applied. Thus improved extension work was considered of great importance and a primary concern to most producers.

Research on force-molting was given a low priority in view of the widespread Canadian preference for a single period of lay followed by flock replacement. Economic factors influence this preference. However, systems of inducing a second period of lay have been well developed in the United States. Canadian egg producers lack experience in applying these procedures and the Canadian marketing system may militate against their use.

Producers view research studies in terms of their own needs, and it was questioned whether their research needs are really being identified. For some producers, the means of effective communication of research findings has not been readily established. While conference participants strongly supported the need for both short- and long-term research, funding by producer organizations and other industry groups may be in the direction of shorter-term projects with more-immediate and clearly defined objectives. Producers tend to give priority to research that promises concrete cost-reducing benefits. It was understood that producer-funded research must take place within the framework of the national egg-production research program, with effective communication between producers, industry and the scientific community.

Animal welfare considerations in the industry are important for both the producer and the public. The conference identified as a high priority the need for unbiased, objective studies of 'what is normal' in the behavior of the laying hen. These studies would provide a means of establishing standards of humane treatment. The conference recognized that there should be a continuing relationship between the egg-production industry and responsible groups

concerned with animal welfare. Producers and public have a clear interest in the added productivity which results from improved research into animal welfare and from the humane treatment of animals. These two objectives are not necessarily in conflict.

Extension

The importance of extension work was stressed consistently throughout the conference discussions. Undisputed was the fact that present knowledge about the improvement of feeding and management practices is underutilized. Extension work is a major subject in itself. The meeting did not study extension methods in any detail. However, the following were noted:

- The roles and responsibilities of governments, universities, producers' organizations and other industry sectors in extension work must be recognized.
- Research must include field trials. This is important in the context of extension work and the degree to which research findings are applied and adapted effectively to commercial requirements, and also to the degree or confidence producers have in extension recommendations.
- It was suggested that ways should be found to make research findings readily available in layman's language to producers. The great volume of research data, and its constantly evolving nature, would make this costly. However, it might be possible to provide layman's interpretations in such a way as to answer the most frequently asked questions concerning the chief problem areas, either by means of a computerized system or brochures.
- Monitoring the actual commercial experience of producers in terms of the particular types of enterprise, including size, equipment, management methods and other procedures, would be a valuable extension tool for informing producers of commercial performance and problems encountered. For scientific purposes, monitoring could be a valuable means of identifying problems that might seem to be random cases if individually experienced, but when occurring nationally or in a geographical region, could be statistically significant. Monitoring could also provide the basis for a useful evaluation of the application of research findings.
- Reliable information on the incidence of a number of diseases of poultry is not well known. This is due to the general rarity of monitoring of poultry diseases other than clinical cases. It was suggested that sub-clinical and endemic diseases should be identified more fully by systematic laboratory examination of live and dead birds from selected flocks. The information gained of disease incidence would provide evidence to producers of the significance of these diseases and the importance of preventive measures. In some cases, disease eradication is possible if the problem is recognized.

Funding

The participants recognized that public funding of research was in a period of restraint. Some budgets were reduced. This posed dangers to the overall adequacy of research funding. It may also lead to neglect of specific types of high-cost research, despite their value and importance. Particular concern was expressed about the funding of universities and their ability to maintain their post-graduate programs. It is also desirable that grants for research and development be available to small companies in the industry. It was reported to the meeting that the Canadian Agricultural Research Council was currently examining research needs and the adequacy of funding for them, an important undertaking.

The constraints on public funding clearly suggested that non-governmental sectors should assess their own responsibilities. However, it was made clear that the meeting did not consider that industry funds could or should be expected to compensate for reductions in public funding. Funds in such major amounts were not likely to be obtained from producers or other private sources. Also, there was considerable public interest in the improved productivity that research provides, and major reliance on public funding should be considered appropriate and essential.

There was specific discussion on the interest of the Canadian Egg Marketing Agency in funding research related to the egg industry. CEMA representatives indicated that participation by the agency in research funding was likely. It was noted also that significant research funding is provided by some provincial producer egg-marketing boards. No concrete decision has been made on the extent of CEMA funding. An important aspect of the interest of CEMA in the conference was to aid consideration of this question by the agency. In carrying out its research-funding activities, CEMA would propose to establish consultative and advisory bodies to ensure consideration by producers of their needs. Coordination with provincial producer boards and federal and provincial governments would be undertaken to ensure correct decision-making in the light of the overall research picture. Advice of the scientific community would be sought in the assessment and development of research proposals. At the conference, the importance of this latter aspect of the process was emphasized, and some relative merits

of funding by grant versus funding by contract were noted.

Consultation and Coordination Processes

It was the hope of the participants that this summary of proceedings and the accompanying working papers would provide a useful source for the ongoing consideration of the egg industry's research and extension needs, challenges and priorities.

Producers, as users of research findings, must make their recommendations and must be heard in the selection of research topics for funding and of research workers. It was suggested at the meeting that CEMA should take the initiative in setting up an ad hoc committee, charged with examining the findings of the workshop and, if desirable, with establishing a permanent form of producer-scientist consultation. The objectives of the initial CEMA committee might be to establish a permanent organization by which egg producers could have an input into the total Canadian egg-production research program; to coordinate the research effort directly pertaining to the industry; and to establish an organized means of disseminating information on research findings to the industry.

The function of the Sub-Committee on Eggs (of the Canadian Agricultural Services Coordinating Committee), should be ascertained, and the possibilities of coordination or overlap with the proposed producer-scientist consultative organization be reviewed. The importance of having all research disciplines represented in such a consultative organization was emphasized.

Observations

In the extremely important area of feeding practices and costs, the following points were noted:

- The major priority was to improve the efficiency of utilization of protein (amino acids) and energy. A large amount of this work involved more-accurate evaluation of available nutrients in feedstuffs and also the characterization of requirements of available nutrients for laying hens.
- Management procedures that reduce the requirement for energy also received relatively high priority. Examples of these included high laying house temperatures and feed restriction programs. For optimum efficiency of feed utilization, an accurate and simple method of measuring feed intake is essential.
- The continued effort to utilize new and alternative sources of energy and protein remained a high-priority item.
- Concern was expressed about a possible future lack of professional expertise to supply the poultry industry with information on nutrition.
- There was a discussion on the possibilities for producers, under high feed price conditions, to profitably reduce the nutrient (particularly protein) intake of their laying flock, even at the expense of producing fewer eggs. It was generally agreed that there is a widespread tendency in the industry to feed unnecessarily high amounts of protein. It was also pointed out that while dietary intake can affect the fat composition and vitamin levels of eggs, there is no evidence that the protein composition of eggs is affected by variations in feed composition in the diet. It was considered that this fact was not as widely understood as it should be.

It was emphasized that some important and current disease problems may be controlled through management techniques with suitable laboratory support and that producers needed more help from laboratories in monitoring their flocks when attempting to control these diseases. It was suggested that research priorities be decided on the basis of the significance of the problem and not whether the problem could be solved by pure research, applied research, field investigation or laboratory monitoring.

Considerable stress was laid, particularly in connection with Marek's disease, on the importance of continuous monitoring and research to guard the industry against risk of the emergence of pathogens that have acquired resistance to present methods of treatment, and to guard against the introduction of pathogens from outside Canada. The concept of a special system of early disease warning was termed a 'diagnostic watch'.

TABLE 18. Future Research Priorities (as determined by conference participants)

Area of research	Priority	Term
GENETICS AND BREEDING		
Research must be continued on methods for improving selection techniques and emphasis must be placed on the development of multi-trait selection programs that include feed efficiency as one of the key traits.	High	Long
Genetic techniques are required for improving eggshell quality, improving general disease resistance, improving persistency in rate of production and post-molting performance, all within selection programs designed to produce a bird with the overall balance of traits needed for efficient production of marketable eggs.	High	Long
Studies on the inheritance of behavioral traits to see if it is possible to select for hens with the type of behavior that favors the production of numerous high-quality eggs.	High	Long
Specific areas of basic research in relation to applied research, e.g., evaluation of biochemical and physiological parameters of direct relevance to selection for economic performance.	High	Long
Genotype-environment interaction research is required to continue and expand this research area; to elucidate a more-detailed understanding of the unique requirements of stocks and strains; to develop specific nutritional and physiological regimes to maximize performance on an ongoing basis; to incorporate more-precise procedures in selection programs to combat stress and to understand why birds differ in their response to different environments.	High	Long
Resources should be made available for identifying and maintaining mutants as they occur in breeding programs, so that their potential for possible industrial use can be explored, and so they can be exploited for research in basic physiology and genetics.	High	Long
NUTRITION: ENERGY AND PROTEIN		
Short-term		
Comparison of the new rapid bioassays for AME (apparent metabolizable energy) and TME (true metabolizable energy) with conventional methods of measuring ME in relation to ease, accuracy and repeatability of determinations, biological performance and cost.	1	Short
Establishment of a standard method of ME determination	2	Short
Adoption of a single type of ME value for expression of energy values of feedstuffs and energy requirements of poultry, in collaboration with a body such as the Expert Committee on Animal Nutrition.	3	Short
Establishment of a standard method of measuring the availability of amino acids in feedstuffs.	4	Short
Work is required to define more exactly the relationships between energy, protein and available amino acid intakes and egg output, with the aim of establishing a comprehensive economic input-output model.	5	Short
Feeding regimes that result in minimum weight gains after maturity should be devised, to reduce maintenance costs and improve bird health. This will involve the development of		

TABLE 18. (continued)

Area of research	Priority (in priority order)	Term
NUTRITION: ENERGY AND PROTEIN (cont'd.)		
practical ways of controlling the energy intake of laying hens and the economic evaluation of restricted feeding programs.	6	Short
Economic evaluation of raising the temperature of the laying house to reduce the energy costs of maintenance.	7	Short
Improvement in the nutritional value of cereal grains and seeds by breeding is dependent on the development of rapid biological and chemical tests for measuring the availability of energy and amino acids in the new crops. Rapid and cheap chemical tests are also required for the routine assay of the nutritive value of feedstuffs and mixed diets.	8	Short
A study of the relative value of corn in layer diets is required. This is a controversial topic in Western Canada and feed manufacturers would like to have more data.	9	Short
The relative merits of feed texture, i.e., pellets, crumbs, and mash, should be established on an economic basis.	10	Short
Investigations should be carried out on feed-processing techniques such as enzyme and heat treatment to improve nutrient availability.	11	Short
Work should be initiated on a study of whole grain, and extended to include moist grain.	12	Short
Influence of sinapine from rapeseed meal on the flavor of eggs.	13	Short
Long-Term		
Establishment of the available amino acid requirements of laying hens.	1	Long
Genetic-nutritional interactions in hemorrhagic liver syndrome and other problems should be investigated.	2	Long
Work need to be continued on the utilization of indigenous proteins, such as rapeseed meal, to reduce the dependence on imported protein feeds. The nutritional value of protein feedstuffs, particularly newer types such as field peas, fababieans and sunflower seed should be established, on an ongoing basis.	3	Long
Basic knowledge of digestion and absorption needs to be extended, with the aim of improving efficiency of feed utilization. For instance, it appears that efficiency of utilization is higher in the pig than in the bird, suggesting a potential for improvement.	4	Long
The potential for the amino acid supplementation of diets should be established.	5	Long
The nutrient requirements of existing and newly introduced strains should be reassessed periodically as new genetic strains are introduced.	6	Long
Establishment of the nutritional value of grains, particularly new varieties, on an ongoing basis.	7	Long
Work needs to be continued on alternative protein sources such as high-protein grains, dehydrated alfalfa, industrial and agricultural wastes and by-products.	8	Long

TABLE 18. (continued)

Area of research	Priority (in priority order)	Term
NUTRITION: MINERALS, VITAMINS AND ANTIBIOTICS		
Minerals		
Reassessment of mineral requirements of all ages of pullet and laying hen.	High	5 years
Selenium requirement of laying hens and carry-over into egg and muscle.	Medium	5 years
Identification of optimum phosphorous requirement of layers and study of calcium metabolism pertaining to shell quality.	Medium	5 years
Use of low-sodium diets to control pullet maturity.	Low	5 years
Study of heavy-metal metabolism in laying hens.	Low	5 years
Vitamins		
Study of vitamin stability with on-farm storage and study of vitamin requirements of layers.	High	5 years
Continuation of present studies on the role of various vitamin D_3 metabolites in calcium and phosphorous balance in relation to shell quality.	Medium	5 years
Study of vitamin E—selenium responsive condition in layers.	Medium	5 years
Study of B-vitamin requirements of chicks, pullets, layers and breeders with emphasis on elucidation of dietary antagonists.	Low	5 years
Antibiotics		
Development of management systems emphasizing less dependence on antibiotics.	Low	5 years
Development of new antibiotics with emphasis on organism resistance, e.g., Salmonella.	Low	5 years
METABOLISM AND ENDOCRINOLOGY		
Calcium metabolism	1. High	Long
Circadian (once per day) rhythms	2. High	Long
Endocrine regulation of egg formation	3. High	Long
Growth and sexual maturity	4. Medium	Medium
Physiological characterization of genetically divergent lines	5. Medium	Medium
Semen freezing	6. Medium	Short
Stress physiology	7. Medium	Long
Thyroid gland	8. Low	Long
Fat metabolism	9. Very low	Long
Force-molting	10. Very low	Short
LAYER FLOCK HEALTH		
Procedures for identifying birds infected with lymphoid leukosis	High	Moderate
Eradication of mycoplasma gallisepticum. Provision of more laboratory facilities to identify infected flocks	High	Relatively short
Development of diagnostic techniques to identify and control disease agents causing abnormal shells and/or production drops (i.e., infectious bronchitis, adenovirus infection, avian encephalomyelitis) and other conditions causing abnormalities of the internal quality of the egg	High	Long

TABLE 18. (continued)

Area of research	Priority	Term
Research on field virus isolates, immune mechanisms and use of vaccines in control of Marek's disease	High	Long
Research on the significance of infectious bursal disease and desirable vaccines for its control	High	Moderate
Improvements in vaccines against infectious laryngotracheitis	Medium	Moderate
Research into development of resistance to drugs used to control coccidiosis and other control methods such as immune mechanisms	Medium	Long
Osteomalacia syndrome	Medium	Moderate
PULLET AND LAYER FLOCK MANAGEMENT		
Shell quality — production of adequate shells — improvement of management and handling techniques	High	
Cage design — study of management and nutritional programs compatible with cage design	High	
Energy conservation — lighting systems — brooding systems — feed efficiency	Medium	Long
Economic feasibility of force-molting layers	Low	
Waste management	Low	
Albumen quality: — more surveys to see what customer really wants — if a real marketing problem exists, study further	Low	
EGG AND LAYER MARKETING		
An efficient sanitation program needs to be devised for egg-grading stations; because of known problems with the washing of eggs, there should be research on alternative means of cleaning eggs, be it a more efficient washing system or a totally different system which eliminates the need for the wet-washing of eggs.	High	
A feasibility study on the effect of bacterial penetration of albumen on quality needs to be undertaken.	High	
A summary of shell research for fieldmen and producers is needed.		
How to improve the peeling of eggs that are oiled.		
Marketing research on a uniform yolk color for Canada.		
Acceptance of new packaging. Should there be more or fewer eggs per package.		
Alternative ways to utilize spent layers.		
Sell eggs by the kilogram.	Low	
Small study to substantiate or revise published tables of values for some key elements in chemical and in nutritional composition of eggs.	Low priority for research, high priority for technology transfer	
Maintain watching brief on cholesterol research.	Low profile	
Consideration should be given to a different (from scanning) type of assessment of interior quality.	Low (industrial problem)	
Retention of interior quality.	Low	

TABLE 18. (continued)

Area of research	Priority	Term
The production of a sound shell is mandatory.	High priority for general research, low ority for marketing research	
BIRD BEHAVIOR AND WELFARE		
Ethogram study to measure 'what is normal' in laying hen behavior.	1	
Improved cage design.	2	
On-farm, detailed environmental and behavioral studies.	3	
Develop a code of practice for handling birds from hatchery to slaughter.	4	
Stockman training at university or community college level.	5	
ENGINEERING AND HOUSING EQUIPMENT AND DESIGN		
Complete systems design: — field study of the performance of the various building and equipment systems on farms — an extension thrust to rush the information available to producers	High	Short
Energy conservation both for the existing facilities and through the development of new technology to be applied to existing and new facilities:		
— an extension thrust in applying ventilating fans that are more energy efficient to existing and new facilities	High	Short
— research to develop ventilation systems that reclaim exhausted heat	High	Short to medium
— assistance to manufacturers in the development of energy-efficient ventilating fans	Medium	Medium
— solar energy	Low to medium	Long
On-farm feed processing and handling.	Extension thrust	
Cage design.	Medium	Long
Egg gathering: an economic comparison between hand gathering and egg belts.	High	Short
Monitoring systems and communication systems Step 1: define the market Step 2: research to develop monitoring systems or packages suitable for the 5000 to 10 000 bird block size. This would likely be in the form of grants to manufacturers for development.	High	Short
Continue to develop new poultry house designs.	Low	Long
Problem of wet manure in high-rise houses: recommend that buildings be developed to accommodate manure in semi-solid form in situ in the barn.	Medium	Medium
Re bird disposal, on-farm storage of dead birds in a freezer is recommended and periodic delivery to dead animal disposal industry.		

ACKNOWLEDGMENTS

The Canaidan Egg Producers Council and the Canadian Egg Marketing Agency wish to acknowledge the contributions of the following specialists who, as author or co-author, have contributed to the section on the assessment of research knowledge and future priorities in egg production and marketing.

Mr. A. B. Allen, Agriculture Canada
Mr. Norman Bird, Ontario Ministry of Agriculture and Food
Dr. Robert Blair, University of Saskatchewan
Dr. Robert J. Etches, University of Guelph
Dr. Robert S. Gowe, Agriculture Canada
Dr. A. T. Hill, Agriculture Canada
Dr. J. R. Hunt, Agriculture Canada
Dr. J. Frank Hurnik, University of Guelph
Dr. Steven Leeson, University of Guelph
Dr. James R. Pettit, Agriculture Canada
Dr. Chesley J. Randall, Agriculture Canada
Dr. John D. Summers, University of Guelph

LIST OF ATTENDEES

Bailey, J., Canadian Egg Marketing Agency, Ottawa, Ont.
Bentley, A. H., Agriculture Canada, Ottawa, Ont.
Bernard, C., FEDCO, Montreal, Que.
Bigland, C. H., VIDO, Saskatoon, Sask.
Bird, N., Ontario Ministry of Agriculture and Food, Stratford, Ont.
Blair, R., University of Saskatchewan, Saskatoon, Sask.
Bouchard, R., Agriculture Canada, Ottawa, Ont.
Boxall, L., Saskatchewan Egg Board, Regina, Sask.
Buckland, R., Macdonald College, Ste. Anne de Bellevue, Que.
Carnine, G., Alberta Egg Board, Calgary, Alta.
Christison, I., B.C. Egg Marketing Board, Cobble Hill, B.C.
Classen, H. L., University of Saskatchewan, Saskatoon, Sask.
Cloutier, B., FEDCO, Montreal, Que.
Colborn, K., Saskatchewan Comm. Egg Producers Marketing Board, Regina, Sask.
Crober, D. C., Nova Scotia Agricultural College, Truro, N.S.
DeLong, R., N.S. Egg Marketing Board, Lunenburg Co., N.S.
Desmarais, M., Ministry of Agriculture, Quebec, Que.
de Valk, R., Consumer and Corporate Affairs, Hull, Que.
Eby, R. K., Agriculture Canada, Ottawa, Ont.
Ellsworth, B., Ontario Egg Producers Marketing Board, Willowdale, Ont.
Etches, R. J., University of Guelph, Guelph, Ont.
Flaten, G., Canadian Federation of Agriculture, Regina, Sask.
Friend, C. L., Canadian Feed Industry Association, Ottawa, Ont.
Gorham, R., N.B. Egg Marketing Board, Fredericton, N.B.
Gowe, R. S., Agriculture Canada, Ottawa, Ont.
Gray, R., Shaver Poultry Breeding Farms Ltd., Cambridge, Ont.
Green, D., Co-operative Federee de Quebec, Montreal, Que.
Grunder, A. A., Agriculture Canada, Ottawa, Ont.
Guenter, W., University of Manitoba, Winnipeg, Man.
Hagborg, J., Canadian Egg Marketing Agency, Ottawa, Ont.
Herbert, B., Alberta Agriculture, Edmonton, Alta.
Hill, A. T., Agriculture Canada, Agassiz, B.C.
Hunt, J. R., Agriculture Canada, Agassiz, B.C.
Hunter, C., Producer, Stroud, Ont.
Hurnik, J. F., University of Guelph, Guelph, Ont.
Hyde, J. S., Canadian Egg Marketing Agency, Huntsville, Ont.
Johnston, G., P.E.I. Dept. of Agriculture, Charlottetown, P.E.I.
Johnstone, J. W., Ontario Egg Producers Marketing Board, Alliston, Ont.
Jotham, N., Canadian Federation of Humane Societies, Ottawa, Ont.
Kristjansson, F., Agriculture Canada, Ottawa, Ont.
Lancaster, J. E., Agriculture Canada, Ottawa, Ont.
Law, H., Canadian Egg Marketing Agency, Ottawa, Ont.
Leeson, S., University of Guelph, Guelph, Ont.
Lentz, W., Canadian Egg Producers Council, Charlottetown, P.E.I.
Long, G., Ontario Egg Producers Marketing Board, London, Ont.
Longstaff, F., Saskatchewan Egg Board, Regina, Sask.
Lukey, O., Alberta Egg and Fowl Marketing Board, Acme, Alta.
Manget, J., B.C. Ministry of Agriculture, Victoria, B.C.
McBride, M., Canadian Egg Marketing Agency, Ottawa, Ont.

McEwan, R., Ontario Egg Producers Marketing Board, Beamsville, Ont.

McIsaac, L., Canadian Egg Producers Council, Charlottetown, P.E.I.

McLeod, A., N.B. Egg Marketing Board, St. Stephen, N.B.

Mitchell, D. V., Manitoba Egg Producers Marketing Board, Winnipeg, Man.

Mitchell, M. S., Agriculture Canada, Ottawa, Ont.

Morrison, J. A., Agriculture Canada, Ottawa, Ont.

Murdoch, R., Canadian Egg Producers Council, Essex, Ont.

Pettit, J., Agriculture Canada, Ottawa, Ont.

Ramey, D., N.B. Dept. of Agriculture, Fredericton, N.B.

Randall, C. J., Agriculture Canada, Ottawa, Ont.

Riddell, C., University of Saskatchewan, Saskatoon, Sask.

Robblee, C., University of Alberta, Edmonton, Alta.

Roytenberg, M., Canadian Egg Marketing Agency, Ottawa, Ont.

Scott, W., Ontario Egg Producers Marketing Board, Seaforth, Ont.

Shires, W., University of Saskatchewan, Saskatoon, Sask.

Waldner, D., Manitoba Egg Producers Marketing Board, Elie, Man.

Wiens, T., Canadian Poultry and Egg Producers Council

Wilkinson, K., National Farm Products Marketing Council, Ottawa, Ont.

Witty, R., Canada Packers Research Centre

No. – N°
630.4 A review of resea
C212 into egg production
P 5126 marketing :
1980
OOAg
c.3